THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Crops Research Division, Plant Industry Station, Beltsville, Maryland
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IN THIS ISSUE

A. P. D. McCLEAN writes that not one example of seed transmission has been observed among thousands of citrus seedlings raised for use as test trees in transmission studies with the tristeza virus in South Africa, page 821.

Best control of the dead-arm disease of grapevines in California resulted from a dormant spray of sodium arsenite followed by a foliar spray of captan applied to the new growth, according to observations reported by T. S. PINE, page 822.

O. D. MORGAN and W. F. JEFFERS report effects of fumigation and heat treatment on strawberry root knot and black root rot, page 825.

Results of cross-inoculations with the burrowing nematode are reported by L. G. Van WEERDT, page 832.

RICHARD A. CHAPMAN tried various methods of aeration to improve yield of Pratylenchus from root samples, page 836.

An outbreak of oat powdery mildew in 1956 provided an opportunity to study reaction of varieties and selections in a nursery in northern Florida, with results reported by H. H. LUKE, W. H. CHAPMAN, and A. T. WALLACE, page 842.

H. R. POWERS, Jr. studied conditions associated with the unusually severe attack of powdery mildew on winter wheat in the Southeast during the 1956-57 season, page 845.

G. J. GREEN and E. R. KERBER report seedling and adult plant reaction of durum wheat varieties to Canadian isolates of wheat stem rust races, with special attention to virulent strains of races 15 and 15B, page 848.

C. O. JOHNSTON lists races of wheat leaf rust identified in the United States in 1956, page 853.

ALICE L. ROBERT and W. J. WISER report occurrence of Puccinia polysora on field corn in the Florida Everglades area, page 856.

Captan proved superior to Arasan for corn seed treatment in tests reported by PAUL E. HOPPE, page 857.

JOHN G. ATKINS describes symptoms of the bakanae disease of rice, which was recently found in Texas for the first time in the United States, page 860.

Results of the 1956-57 small grain disease surveys in South Carolina are reported by R. W. EARHART, page 863.

ISAAC MALCA M. and JOHN H. OWEN report studies on the gray leaf spot of St. Augustine grass, page 871.

Bacterial stem blight of alfalfa caused severe damage in Missouri in 1957, according to MARVIN D. WHITEHEAD and EMMETT L. PINNELL, page 876.

R. S. COX and N. C. HAYSLIP report recent developments in the control of tomato foliage diseases in southern Florida, page 878.

The Tropic Wonder pole bean variety did not prove resistant to races of bean rust occuring in Puerto Rico, in trials reported by T. THEIS, L. CALPOUZOS, and E. CABANILLAS, page 884.

W. E. SACKSTON reports diseases observed on sunflowers in Uruguay during field trips in 1956-57, page 885.

D. DAVIS and S. HALMOS report some studies of the effect of gibberellin on plant diseases, page 890.

Observations reported by ERNEST WRIGHT support the conclusion that Cytospora canker of cottonwood affects trees that are declining in vigor, page 892.

ELLIS B. COWLING lists fungi reported as having been associated with decay of wood products in the United States, page 894.

MARLIN N. ROGERS gives directions for the construction and use of a small electrical hygrometer for microclimate measurements, page 897.

IN THIS ISSUE (Continued), page 905.

Vol. 41, No. 10--PLANT DISEASE REPORTER--Oct. 15, 1957

TRISTEZA VIRUS OF CITRUS: EVIDENCE FOR ABSENCE OF SEED TRANSMISSION

A. P. D. McClean

At Pretoria during the past 8 years, many thousands of citrus seedlings have been raised for use as test trees in transmission studies with tristeza virus. Most, if not all, orchard trees in South Africa are infected with tristeza virus in one form or another; and it can be safely assumed that virus is present in all the parent trees from which seed was collected.

The species most commonly used in the studies is the small acid lime, known in South Africa as the West Indian lime. The same variety is known in other countries under the names of Mexican lime, Key lime, Egyptian lime, and Limão Galego. Because of distinctive symptoms that develop in the leaves and wood this lime has become the standard indicator for tristeza virus. All the parent trees in South Africa used as a source of seed are definitely known to be infected with tristeza virus. But not one example of transmission of the virus through the seed has been observed among the many thousands of seedlings raised. The seedling progeny from any batch of seed always include a small proportion of runty and abnormal individuals. Some abnormal seedlings were tested by grafting pieces of them into normal seedlings, but they were never found to contain anything transmissible.

Grapefruit seedlings when infected artificially develop symptoms of pitting in the wood and often cleared zones in the veins of newly formed leaves. But among the large number of seedlings raised no example has ever been observed of any abnormality to suggest that tristeza virus had passed through the seed. The same has been true of seedlings of the citron and varieties of sweet lime, all of which have been found to react with wood-pitting after being experimentally infected.

Seedlings of species like the sweet orange, mandarin, rough lemon, and some varieties of tangelo when infected artificially usually show no reaction at all. In consequence the health of seedlings raised from the seed of infected parents cannot be determined merely on their appearance, and inoculation is necessary to a sensitive species. In every instance that untreated control plants of sweet orange, mandarin, rough lemon, and tangelo were tested for tristeza virus by graft inoculation to seedlings of the West Indian lime, the result has been negative. In the course of 8 years some hundreds of seedlings have been tested in this way.

DIVISION OF PLANT PATHOLOGY, DEPARTMENT OF AGRICULTURE, PRETORIA, SOUTH AFRICA

THE USE OF CAPTAN IN THE CONTROL OF THE DEAD-ARM DISEASE OF GRAPES

T. S. Pine[1]

Historically, heavy pruning beyond the portions showing symptoms of dead-arm (Phomopsis viticola Sacc.) has been the recommended control. Bordeaux mixture has been used early in the growing season, applied to trunks and green shoots (1, 6) and a Lime sulfur spray has been reported effective in some areas (2, 5). In California, Hewitt (3, 4) found sodium arsenite (equivalent to 3 pounds arsenic trioxide in 100 gallons of water), applied to the vines as late in the dormant season as possible, provided adequate control.

It was felt that a foliar spray, applied to the young growth, might give added protection to the new shoots and berry clusters. In 1955, the following materials were sprayed on randomized blocks of Tokay vines in the Lodi district of San Joaquin County, repeated in three vineyards: Captan 50-W (N-trichloromethylthio)-4-cyclohexene-1, 2-dicarboximide); Dithane D-14 (disodium ethylenebis (dithiocarbamate)); Acti-dione (cycloheximide); Manzate (manganous ethylenebis (dithiocarbamate)); Dithane D-14 to which was added the sulfate salts of zinc, iron, and manganese. These materials were used when the vines were 6 inches or less in length. Blocks of 20 vines, replicated five times, were used for each treatment, an equal number being left as a check. All applications were made with a hand-operated power sprayer, used at a nozzle pressure of approximately 200 pounds per square inch. In late June, 1955, each vine was rated for its general disease expression, based upon the following scale: 0 = less than 5 percent of the new canes infected; 1 = 5 to 25 percent; 2 = 25 to 50 percent; 3 = 50 to 75 percent; 4 = more than 75 percent infected. The materials used, rates of application, and the resulting treatment means are summarized in Table 1. There was a slight amount of leaf blistering and tattering on vines sprayed with Captan or Dithane, but no injury to the berries.

Table 1. Results obtained in 1955 from several foliage sprays used against dead-arm on Tokay grapevines.

Material used	Application rate in 100 gals. water	Treatment means [a]
check		2.64
captan 50-W	2 lbs.	0.78
dithane D-14 plus salts	1 gal. plus 2 lbs.	1.39
dithane D-14	½ gal.	1.84
acti-dione	1 ppm	2.07
manzate	2 lbs.	2.13

[a] Rated as: 0 = less than 5 percent infection; 1 = 5-25 percent; 2 = 25-50 percent; 3 = 50-75 percent; 4 = more than 75 percent infection. L. S. D. at 0.05 was 0.76; at 0.01 it was 1.03.

Inasmuch as Captan gave the best results, an attempt was made in 1956 to determine more precisely the best time of application, and the amount of material necessary to protect the new growth. In randomized blocks of Tokays, again in the Lodi region, Captan 50-W was applied at 0.5 to 2.5 pounds per 100 gallons of water, on growth ranging from green buds to 15 inches. Each treatment was applied to 25 vines, application being in the same manner as mentioned above. One trial consisted of spraying the vines twice, the first time at 6 to 8 inches of growth

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Table 2. Results obtained in 1956 when Captan 50-W was applied at different concentrations and at several stages of shoot growth.

Lbs. captan in 100 gals. water	Shoot growth in inches	Treatment means [a]
0.5	6-8	2.26
1.0	6-8	2.00
1.5	6-8	2.06
2.0	bud	1.26
2.0	1	1.20
2.0	6-8	2.20
2.0	8-12	2.20
2.0	12-15	2.86
2.0	6-8 and 12-15	2.66
check		3.00

Rated as: 0 = less than 5 percent infection; 1 = 5-25 percent; 2 = 25-50 percent; 3 = 50-75 percent; 4 = more than 75 percent infection.
L. S. D. at 0. 05 was 0. 72; at 0. 01 it was 0. 98.

and the second at 12 to 15 inches. After 3 months, the vines were examined for disease symptoms, and rated on the 0 to 4 scale. The results of this experiment are shown in Table 2.

The data gathered in 1955 and 1956 indicated clearly that the use of a foliar spray was beneficial in protecting the new growth. This was important for two reasons: 1) the young clusters were protected, thus insuring a larger crop during the current season, and 2) the growth at the base of new canes, commonly left as bearing units for the following season and acting as a source of inoculum, was kept cleaner. No experimental plots were designed to test combinations of dormant and foliage sprays, but observations were made in 1956 at several vineyards in which sodium arsenite and Captan had been applied by the growers. A dormant spray of sodium arsenite in February-March, 1955, did not protect the vines from infection in 1956, when no sprays of any kind were used in the spring of 1956. When sodium arsenite was used in 1955 and 1956, disease incidence dropped to approximately 35 percent. Sodium arsenite used both years, plus Captan at 1 to 2 inches of new growth in 1956, reduced dead-arm to less than 5 percent of the total vines sprayed. It was thus evident that only partial control was gained through annual use of only a dormant spray, and also that a certain amount of control was gained by using only a foliar spray. However, maximum protection was obtained when the two were used in combination, if the foliar spray was applied when the new shoot growth was 1 to 3 inches long.

Literature Cited

1. COLEMAN, L. C. 1928. The dead-arm disease of grapes in Ontario. A preliminary study. Scient. Agric. 8: 281-315.
2. du PLESSIS, S. J. 1938. The occurrence of the dead-arm disease of vines in South Africa. Union of South Africa Dept. Agr. & For., Sci. Bul. 175: 1-9.
3. HEWITT, W. B. 1947. Sodium arsenite, a promising control of dead-arm of grapes. (Abst.) Phytopathology 37: 362.
4. HEWITT, W. B. 1951. Grape dead-arm control. Plant Dis. Reptr. 35: 142-143.

5. HIURA, M. 1924. On the root-neck blight of the vines near Sapporo. Jour. Agr. For. Soc., Sapporo, 16: 63-78. (English summary).
6. REDDICK, DONALD. 1914. Dead-arm disease of grapes. New York Agr. Expt. Sta. Bul. 389: 463-490.

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THE EFFECTS OF FUMIGATION AND HEAT TREATMENT ON ROOT-KNOT NEMATODE AND BLACK ROOT ROT OF STRAWBERRIES

O. D. Morgan[1] and W. F. Jeffers[2]

Abstract

Treatment of the Robinson strawberry variety with the soil fumigant 1, 2-dibromo-3-chloropropane at 68 and 136 pounds of 25 percent material per acre, following a fall treatment with 60 gallons D-D per acre, on heated and non-heated planting stock gave excellent control of root-knot nematode (Meloidogyne hapla). The low rate was as effective as the high rate. A fall treatment with two 30-gallon applications of D-D 10 days apart gave unsatisfactory control of root-knot nematode. Heat treatment of plants alone was unsatisfactory due to the presence of parasitic nematodes in the soil. The number of daughter plants per acre from non-heated plants, regardless of soil fumigant, was significantly higher than from heated plants. Control of black root rot with all treatments was inconclusive.

INTRODUCTION

During recent years 1, 2-dibromo-3-chloropropane, formerly known as OS 1897 and now known as Nemagon, has been tested as a soil fumigant for the control of nematodes. Raski (21) showed that OS 1897 gave effective control of root-knot nematode and controlled Pratylenchus as well as D-D and better than EDB (ethylene dibromide) on grape replants. However, Raski reports that at 10 gallons per acre, OS 1897 caused injury. McBeth and Bergeson (15) found that 1, 2-dibromo-3-chloropropane was 8 to 16 times as effective as D-D and 2 to 5 times as effective as EDB for control of root-knot nematode. They also list crops tolerant of and sensitive to the fumigant. Control of the root-knot nematode, Meloidogyne hapla Chitwood, on strawberry (variety Stelemaster) with Nemagon was demonstrated by Potter and Morgan (20). Ichikawa et al. (12) studied the diffusion of 1, 2-dibromo-3-chloropropane; he found no nematocidal effect after 1 week but the effect was present from 2 to 9 weeks.

Aycock (2) reported that Nemagon at 1.2 cc per linear foot gave best control of root knot on cantaloupe but caused injury, whereas, Lear and Raski (14) found that dosages of Nemagon under 20 gallons per acre did not penetrate roots of grape and tomato sufficiently to control root knot. Foster and Baxter (6) found that 8 gallons of Nemagon per acre gave good control of root-knot nematode on peach and did not injure the plants. Gilpatrick et al. (7) reported Nemagon at 4- to 8-inch depths gave equally good control of root knot of squash when applied as liquid (1.25 gallons) or as a granular material (21.6 pounds) per acre. Miller (19) was unable to control black root rot of strawberries with Nemagon at 4 gallons per acre applied as a preplant and side-dressed treatment. Allen and Raski (1) used 80 gallons of D-D to control meadow nematode but they found that the nematode population started building up again after 4 months.

Other means of nematode control, such as heat treatment, have been tried by Hodson (11) and Danish workers (5) with varying degrees of success. Goheen and McGrew (8) were able to control endoparasitic root nematodes in strawberry propagation stocks by a hot-water treatment of 127° F for 2 minutes on dormant Blakemore plants returned to cold storage before planting. Most mother plants survived this treatment and the number of runner plants produced during the summer was not significantly different from that of the untreated control plants.

Another problem that appears to be at least partially related to nematode injury is black root rot of strawberries. Early reports by Strong and Strong (22), Truscott (23), Miller (16, 17, 18), Butler and King (4), noted numerous fungi and other factors in the environment that

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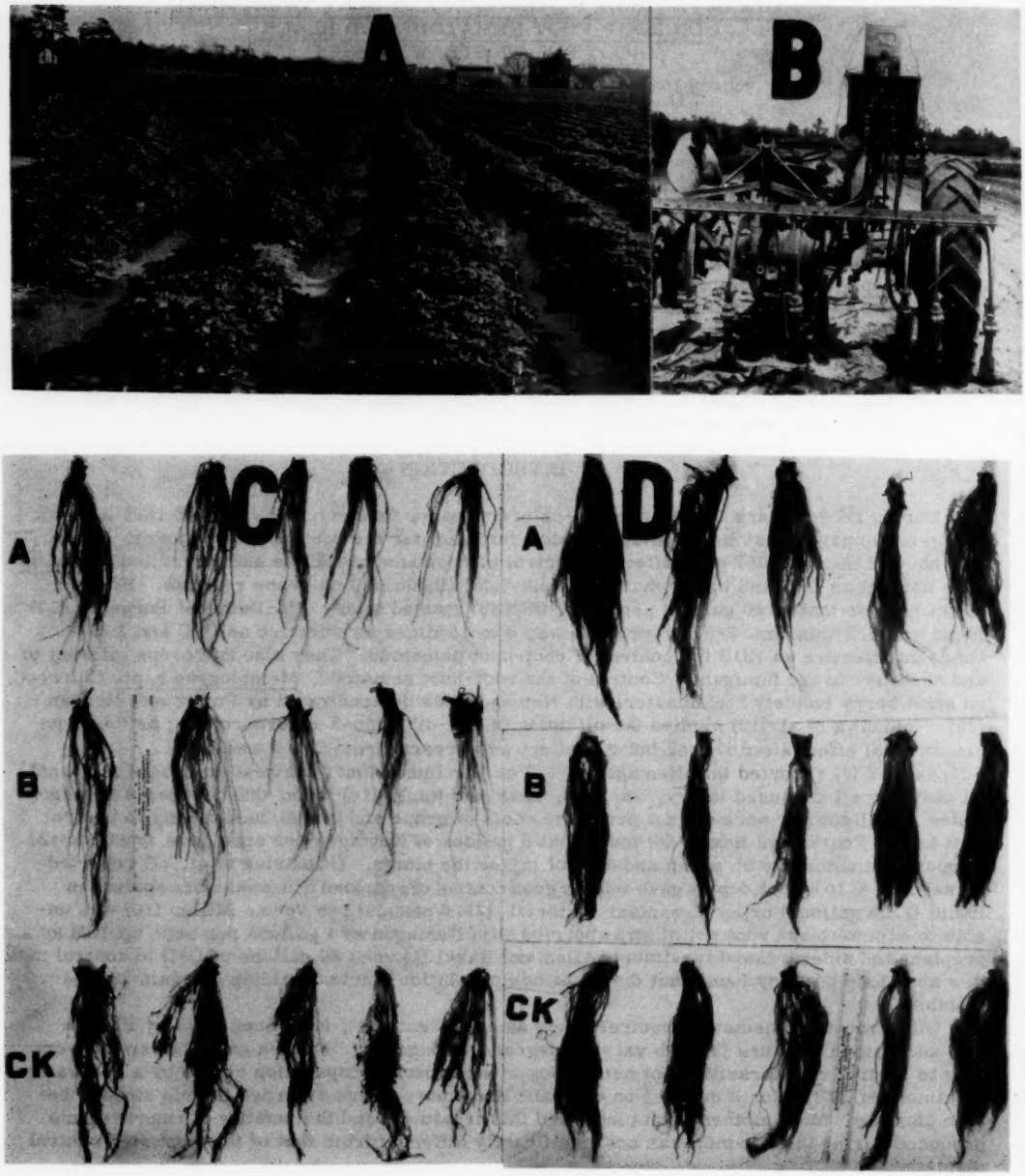

FIGURE 1. A -- Strawberry field of Robinson variety used in tests. B -- Equipmen. used in treating soil with 1, 2-dibromo-3-chloropropane, liquid and granular. C -- Roots of daughter plants from unheated parent stock; small size is due to crowding. D -- Roots of daughter plants from heated parent stock; large size due to less crowded conditions caused by high mortality of parent in heat treatment. CA and DA high rate, CB and DB low rate, of 1, 2-dibromo-3-chloropropane; CK no treatment.

caused black root rot of strawberries. Berkeley and Lauder-Thomson (3), Hildebrand (9), Hildebrand and Koch (10) stated that nematodes were a factor in the root rot complex. Klinkenberg (13) reported that the black root rot of strawberries in the Netherlands was due to nematodes.

The use of soil fumigants for nematode control has been slow, partly due to the lack of proper equipment and cost of application and partly due to the waiting period between treatment and planting. There is a need for a material that can be applied directly to the soil beside the roots of living plants. Vegetable growers and others in Maryland are interested in a fumigant that can be applied with the seed or to transplants with fertilizers when desired.

MATERIALS AND METHODS

The test area, Figure 1A, consisted of about 4 acres. The soil was of sandy loam texture and was known to be heavily infested with Meloidogyne hapla and Pratylenchus sp. In October, 1955 two 30-gallon applications of D-D were made at 10-day intervals by the plow-sole method to the entire field. Rye was planted late in the fall but made very little growth. In February, 1956, about one-half of the Robinson variety strawberry planting stock used in these tests was heat treated at 127° F for 2 minutes. The plants were replaced in cold storage until the first week of April when the test area was planted. There were 81 rows varying from 550 to 650 feet in length in this test. Thirty-nine rows were planted with heat-treated stock while the other 42 rows were planted with non-heated stock.

On June 13 the low rate of 68 pounds per acre of 25 percent granular 1,2-dibromo-3-chloropropane (Nemagon) was applied. The high rate of 136 pounds per acre was applied June 20. At this time the mother plants had become well established and a few runner plants were beginning to form. The material was banded along the rows about 6 inches on either side of the plants, at a depth of about 4 inches. The fumigant was applied with a small Gandy spreader (Figure 1B), equipped with an accurate calibration system, and mounted on a standard Ferguson cultivator. Single-row plots, replicated five times, were treated with the two rates of Nemagon in the block of heated stock. The high and low rates were alternated with each other and separated by three untreated rows.

Since the grower wanted to treat most of the non-heated plants with Nemagon, the method of treatment in this section was somewhat different from the section planted with heated stock. The low rate of granular fumigant was applied in five replicates, of five rows each, alternating with five replicates, of two rows each, of the high rate. There were three replicates, of two rows each, of untreated rows.

Approximately 5 months after treatment with granular 1,2-dibromo-3-chloropropane, 50 plants were pulled at random from each replicate of each treatment. These plants were brought to the laboratory where the tops were cut off and the roots washed. A total root count per treatment was made and the average number of roots per plant determined. Each root was observed, through a large 3x hand lens, for root-knot galls and black root rot. Four-gram samples of root tips from each replicate were cut into small pieces and put into petri plates with about 1/4 inch of water. Average nematode counts were made on each treatment. A plant count was made from nine 1-yard sections of rows per treatment picked at random.

RESULTS

All data given in the tables are from daughter plants. Field observations had indicated that the plants from non-heated stock in general were smaller than the plants from the heat-treated stock. However, the yield from non-heated plants was more numerous and crowded than from the heated plants. The weight and size of the daughter plants from the non-heated stock indicated that the crowded condition was detrimental to good growth. Figure 1, C and D, shows the difference in size of the roots of daughter plants from heat-treated as compared to non-heated parent stock. The number of plants per yard of row in the "non-heated rows" was much higher than in the "heat-treated rows," regardless of treatment with soil fumigants. The data indicate that heat treatment of the Robinson variety reduced the original stand through injury and thus resulted in fewer plants per acre. The larger size of the plants in the heat-treated block can be attributed to the less crowded conditions of the plants.

The relationship between root-knot infection and treatment is shown in Table 2. The high percentage of roots and daughter plants showing root-knot galls from the non-heated check plants is probably due in part to the mother plants having root knot. This is shown by the fact

Table 1. The effect of treatment with 1, 2-dibromo-3-chloropropane, following D-D, on heated and non-heated strawberry roots with respect to plant and root numbers, dry weight, and plant yield.

Treatment	Plant count per treatment	Total root number	Roots per plant	Mean dry weight of roots per plant	Mean number[a] of plants per yard of row
Heated					
Hi rate[b]	244	4284	17.5	1.234	195
Lo rate	247	4704	19.1	1.401	187
Check	250	4312	17.2	1.213	188
Non-heated					
Hi rate	250	4378	17.5	0.855	253
Lo rate	248	4330	17.1	0.898	248
Check	249	4178	17.2	0.923	255
LSD at 5%		ns	ns	0.113	28.8
LSD at 1%				0.153	38.5

[a] Number of plantsper acre per treatment is found by multiplying by the factor 4148.
[b] Rates used, Hi at 136 pounds, Lo at 68 pounds,per acre of a 25% 1, 2-dibromo-3-chloropropane.

Table 2. The effect of treatment with 1, 2-dibromo-3-chloropropane following D-D on heated and non-heated strawberry roots with respect to galled roots and percentages of each.

Treatment	Total number of galled roots[a]	Percent of roots galled	Total number of plants galled	Percent of plants galled
Heated				
Hi rate[b]	6	0.140	4	1.64
Lo rate	2	0.042	2	0.81
Check	818	18.980	106	42.40
Non-heated				
Hi rate	21	0.480	7	2.80
Lo rate	8	0.190	5	2.01
Check	1722	41.210	166	66.67
LSD at 5%	447.7		52.9	
LSD at 1%	608.3		78.9	

[a] See Table 1 for total root and plant numbers.
[b] Rates used, Hi at 136 pounds, Lo at 68 pounds, per acre of a 25% 1, 2-dibromo-3-chloropropane.

Table 3. The effect of treatment with 1, 2-dibromo-3-chloropropane following D-D on heated and non-heated strawberry roots with respect to black root-rot and plants and percentages of each.

Treatment	Total black rotted roots[a]	Percent of black roots	Black rotted plants	Percent of plants with black rot
Heated				
Hi rate[b]	764	17.84	125	51.2
Lo rate	851	18.10	149	60.3
Check	818	18.97	154	61.6
Non-heated				
Hi rate	435	9.94	113	45.2
Lo rate	477	11.02	138	55.7
Check	858	20.54	163	65.5
LSD at 5%	350.6		27.2	
LSD at 1%	ns		37.0	

[a] See Table 1 for total roots and plant numbers.
[b] Rates used, Hi at 136 pounds, Lo at 68 pounds, per acre of a 25% 1, 2-dibromo-3-chloropropane.

Table 4. Mean indexes of Pratylenchus spp. and other nematodes from a 4-gram wet weight root tip sample per treatment.

Treatment	Pratylenchus spp.	Rhabditis, Cephalobus, Dorylaimus and other nematodes
Heated		
Hi rate[b]	Rare[a]	Occasional
Lo rate	Occasional	Occasional
Check	Frequent	Frequent
Non-heated		
Hi rate	Occasional	Occasional
Lo rate	Occasional	Frequent
Check	Frequent	Abundant

[a] Rare 1-10, occasional 11-50, frequent 51-150, abundant over 150.
[b] Rates used Hi at 136 pounds, Lo at 68 pounds, per acre of a 25% 1, 2-dibromo-3-chloropropane.

that the daughter plants from the mother plants in the check rows had significantly fewer galls than those from the non-heated check plants. Since 42.4 percent of the daughter plants in the heated check were infected, it would appear that D-D treatment in the previous fall did not control the nematodes sufficiently to prevent a build-up over the long growing season. This is further indicated by the 66.67 percent of the daughter plants with root knot in the "non-heated check." By treatment with 1,2-dibromo-3-chloropropane it was possible to reduce the nematode population greatly. The root-knot galls in check rows where plants had been heat-treated were generally very small as compared to the non-heated checks. The small size of the galls indicates that infection from a build-up of nematodes after D-D treatment occurred late in the season. All galls on plants treated with Nemagon were small, indicating that early infections were stopped by this fumigant. Since treatment with Nemagon was approximately 2 months after planting, early infection was a possibility. Late infections were controlled by the long action effect of 1,2-dibromo-3-chloropropane as shown by Ichikawa et al. (12).

The mean number of diseased roots with black root rot and of diseased plants, and the percentage of roots and plants with black root rot, are given in Table 3. The total number of roots and plants from which these data were taken is given in Table 1. A review of the literature indicates that fungi, weather and other environmental conditions, and nematodes, or combinations of these, may cause a blackening of the roots. There is a slight indication of control from the high rate of Nemagon in the heated and non-heated rows (10.4 and 20.3 percent less disease than their respective checks). The results given in Table 3 are correlated with the mean index of Pratylenchus control (one possible cause of black root rot) as shown in Table 4, which indicates a trend toward control of nematode numbers. In Table 4 there is some indication of a reduction in numbers of other nematodes.

DISCUSSION

The standard treatments of soil fumigation with D-D and heat treatment of strawberry plants for nematode control are expensive, often injurious to small plants, and sometimes ineffective. When 1,2-dibromo-3-chloropropane (Nemagon) was applied during the growing season as a side-dressing treatment regardless of previous treatments, nematodes were controlled.

Allen and Raski (1) showed that D-D at 80 gallons per acre in split application controlled meadow nematode for only 4 months in a strawberry field. One can assume that 60 gallons per acre in a split application would give less control of both root-knot and meadow nematode. The long growing season from April to October would allow a build-up of endoparasitic nematodes to a point where damage occurs. Data given in this paper would indicate that this is true where the planting stock had been heat-treated. Heat treatment of strawberry stock is of little value when planted in nematode-infested soil. The data presented show that neither D-D nor heat treatment give satisfactory control.

Only when 1,2-dibromo-3-chloropropane was applied during the growing season, in addition to previous treatments, was satisfactory control obtained. Ichikawa et al. (12) found no nematocidal effect 1 week after treatment with 1,2-dibromo-3-chloropropane; however, the nematocidal effect increased from the second week up to the ninth week, indicating that the material is long-acting. The time elapsing between treatment and sampling is important in evaluating this material. One may assume that earlier treatment, perhaps 1 month after planting instead of 2 months after planting, would give better control. In general, the data presented here and data from other investigators indicate that, regardless of type of treatment, all fumigants and methods so far used on a field scale give only partial control of parasitic nematodes. Previous work in Maryland showed that the liquid or granular 1,2-dibromo-3-chloropropane at equivalent dosages gave equal control of root knot.

Literature Cited

1. ALLEN, M. W., and D. J. RASKI. 1952. Nematodes on strawberries. California Agr. 6: 3, 14.
2. AYCOCK, ROBERT. 1955. A comparison of two methods of row fumigation for control of root knot of cantaloupe in South Carolina. Plant Dis. Reptr. 39: 607-610.
3. BERKELEY, G. H., and ISOBEL LAUDER-THOMSON. 1934. Root rots of strawberry in Britain. The "black lesion"

type of strawberry root rot. Jour. Pomology & Hort. Sci. 12: 221-246.

4. BUTLER, E., and T. H. KING. 1951. Strawberry root rot in Minnesota. Plant Dis. Reptr. 35: 238-239.
5. DENMARK. Statens Forsøgsvirksomhed i Plantekultur. 1954. Forsøg med varmtvandsbehandling af Jordbaerplanter med henblik pa bekaempelse af jordbaeral. Denmark. Stat. Forsøgsvirks. i Plantekult. Medell. 517, 4 pp.
6. FOSTER, H. H., and L. W. BAXTER. 1956. Studies on control of peach root knot with Nemagon in South Carolina. Plant Dis. Reptr. 40: 400-402.
7. GILPATRICK, J. D., S. T. ICHIKAWA, MASON TURNER, and C. W. McBETH. 1956. The effect of placement depth on the activity of Nemagon. Phytopathology 46: 527-531.
8. GOHEEN, A. C., and J. R. McGREW. 1954. Control of endo-parasitic root nematodes in strawberry propagation stocks by hot-water treatments. Plant Dis. Reptr. 38: 818-826.
9. HILDEBRAND, A. A. 1934. Recent observations on strawberry root rot in the Niagara Peninsula. Can. Jour. Res. 11: 18-31.
10. HILDEBRAND, A. A., and L. W. KOCH. 1936. A microscopical study of infection of the roots of strawberry and tobacco seedlings by micro-organisms of the soil. Can. Jour. Res. C 14: 11-26.
11. HODSON, W. E. H. 1933. Hot water treatment of strawberry plants. Fruit-grower. (Brit.) 75: 167-168.
12. ICHIKAWA, S. T., J. D. GILPATRICK, and C. W. McBETH. 1955. Soil diffusion pattern of 1,2-dibromo-3-chloropropane. Phytopathology 45: 576-578.
13. KLINKENBERG, CAROLINE H. 1955. Nematode diseases of strawberries in the Netherlands. Plant Dis. Reptr. 39: 603-606.
14. LEAR, BERT, and D. J. RASKI. 1956. Survival of root-knot in grape and tomato roots recovered from soils fumigated with Nemagon. (Abst.). Phytopathology 46: 18.
15. McBETH, C. W., and G. B. BERGESON. 1955. 1,2-dibromo-3-chloropropane, a new nematocide. Plant Dis. Reptr. 39: 223-225.
16. MILLER, P. W. 1947. Fungi associated with root lesions of the strawberry in Oregon. Plant Dis. Reptr. 31: 90-99.
17. MILLER, P. W. 1948. Studies on the cause of strawberry root rot in Oregon. Plant Dis. Reptr. 32: 309-316.
18. MILLER, P. W. 1949. Strawberry root rots. Plant Dis. Reptr. Suppl. 184: p. 191.
19. MILLER, PATRICK M. 1956. Control of black root-rot of strawberries with nematocide-fungicide combinations. Plant Dis. Reptr. 40: 45-47.
20. POTTER, H. S., and O. D. MORGAN. 1956. Nemagon control of root-knot nematodes on strawberries. Plant Dis. Reptr. 40: 187-189.
21. RASKI, D. J. 1954. Soil fumigation for the control of nematodes on grape replants. Plant Dis. Reptr. 38: 811-817.
22. STRONG, F. C., and M. C. STRONG. 1931. Investigations on the black root of strawberry. Phytopathology 21: 1041-1061.
23. TRUSCOTT, J. H. L. 1934. Fungous root rots of the strawberry. Can. Jour. Res. 11: 1-17.

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STUDIES ON THE BIOLOGY OF RADOPHOLUS SIMILIS (COBB) 1893, THORNE 1949, PART I.

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The host list of the burrowing nematode, Radopholus similis, includes plants belonging, taxonomically, to widely separated genera as reported by Birchfield (1), Brooks (2), Feder and Feldmesser (6), and Godfrey (7). Cross-inoculations with nematodes obtained from plants reported as hosts of R. similis, however, have given rise to inconsistencies according to Du-Charme and Birchfield (5). Current investigations are being conducted in order to obtain more information on the host range of the burrowing nematode by making inoculations involving several species of plants. Collateral studies involve the morphological variability of these nematodes as exemplified by single female progenies. Life history studies of R. similis will also be reported.

CROSS-INOCULATIONS

Separate populations of burrowing nematodes were collected, in the manner described by Young (8), by incubating naturally infected roots of boxwood, Buxus microphylla var. japonica; calathea, Calathea lietzei; ginger lily, Hedychium coronarium; cavendish banana, Musa nana; pothos, Scindapsus aureus; and sweet orange, Citrus sinensis; on Rough lemon, Citrus limon, rootstock. Only roots attached to plants were used for incubation.

In a preliminary experiment 36 Rough lemon seedlings, grown in steam-sterilized soil, were divided into six groups of six plants each. Each group of six plants was inoculated with 100 Radopholus similis specimens per plant in 10 cc of water. The nematodes were obtained from the six hosts mentioned above. Thirty-six non-inoculated Rough lemon seedlings were used as controls. Simultaneously six boxwood and six calathea plants were inoculated in the same manner with 100 R. similis specimens per plant, collected respectively from infected boxwood and calathea. Boxwood and calathea free of nematodes served as controls. After six months the roots and surrounding soil were examined for burrowing nematodes, the soil by employing the modified Baermann funnel technique described by Christie and Perry (4) and the roots by dissection and incubation. The results are recorded in Table 1.

Table 1. Number of burrowing nematodes on Rough lemon 6 months after inoculation with 100 specimens per plant from indicated sources.

Source of burrowing nematodes	Inoculated host plant	Number of plants inoculated	Number of R. similis recovered
Boxwood	Rough lemon	6	0
Calathea	" "	6	0
Ginger lily	" "	6	0
Banana	" "	6	0
Pothos	" "	1	2
	" "	5	0
Sweet orange	" "	1	143
	" "	1	8
	" "	1	7
	" "	3	0
Boxwood (control)	Boxwood	6	Thousands
Calathea (control)	Calathea	6	Thousands

[1]The author is indebted to Drs. B. G. Chitwood and G. F. Weber for helpful advice and criticism of the manuscript.

Table 2. Number of infected plants 5 months after inoculation with Radopholus similis (4 plants inoculated in each case).

Source of inoculum	Plant inoculated	Number of infected plants after 5 months
Boxwood	Boxwood	4
Calathea	Calathea	4
Ginger lily	Ginger lily	3[a]
Banana	Banana	4
Pothos	Pothos	4
Citrus	Citrus	2
Citrus	Banana	4
Citrus	Boxwood	4
Citrus	Calathea	4
Citrus	Pothos	4
Boxwood	Citrus	0
Calathea	Citrus	1
Banana	Citrus	0
Pothos	Citrus	0 (1 male in soil)
Boxwood	Calathea	4
Boxwood	Pothos	4
Calathea	Boxwood	4
Pothos	Calathea	4

[a] One plant had died.

Half of the Rough lemon seedlings inoculated with Radopholus similis obtained from an infested sweet orange grove were free of burrowing nematodes after 6 months and none supported a large population. The rough lemon seedlings inoculated with burrowing nematodes from hosts other than citrus had no R. similis specimens after 6 months, except for two specimens in the case of pothos. All the inoculated boxwood and calathea supported a good population of the nematodes amounting to thousands of individuals per plant. All controls were free of burrowing nematodes.

A second cross-inoculation experiment was conducted involving the following six plants: boxwood, calathea, ginger lily, banana, pothos, and sweet orange. An attempt was made to increase Radopholus similis populations on the same species of host from which the inoculum originated and also on some or all of the five other hosts. The citrus (Rough lemon) seedlings were inoculated with nematodes from sweet orange on Rough lemon rootstock as the original source. Inoculations were made as in the first experiment. Due to lack of greenhouse space the experiments were conducted over a period of 13 months. After 5 months the burrowing nematodes were counted by examining the soil and incubating the roots. In all cases only soil surrounding infected roots was infested with burrowing nematodes, except that one Rough lemon seedling inoculated with burrowing nematodes from pothos was free while the surrounding soil contained one male Radopholus similis specimen. The results are summarized in Table 2.

The population of nematodes on boxwood and calathea was always abundant, especially on boxwood. On banana, pothos and ginger lily the populations were considered good, and on Rough lemon seedlings they were sparse or absent.

In a third inoculation experiment 50 corn seedlings (Zea mays, variety Bantam), and 20 tomato seedlings (Lycopersicon esculentum variety Rutgers), grown in 4-inch pots in steam-sterilized soil, were inoculated with Radopholus similis by placing infected citrus roots in contact with the corn and tomato roots. The corn and tomato roots were washed clean 2 months later and incubated for 4 to 5 days. In all cases burrowing nematodes were recovered. None were found in the non-inoculated controls. The nematodes obtained from these corn and tomato plants were used to inoculate ten Rough lemon seedlings. After 3 months no burrowing nematodes could be recovered from the citrus roots in nine out of the ten cases.

Table 3. Source of inoculum, plants inoculated, number of specimens of Radopholus similis recovered after 5 to 8 months, and condition and weight of roots of inoculated plants.

Source of nematodes	Number months elapsed	Number of inoculated host plants per pot	Number of nematodes recovered	Condition of roots	Combined weight of roots (grams)
Citrus soil with R. similis					
1)	5	3 sour orange	0	Poor	1.5
	5	3 " "	0	Poor	1.2
	5	3 " "	0	Poor	1.0
	5	3 boxwood	13	Fair	6.0
2)	8	3 boxwood	3946	Fair	10.4
	8	3 sour orange	29	Fair	30.0
	8	3 " "	0	Poor	18.5
	8	3 " "	1	Fair	29.0
3)	8	3 Rough lemon	0	Poor	5.5
	8	3 sour orange	0	Fair	25.0
	8	3 boxwood	2412	Good	17.0
	8	3 sour orange	12	Fair	17.5
Control (same soil steam-sterilized)					
4)	8	3 sour orange	0	Good	105.5
	8	3 " "	0	Good	101.0
	8	2 sour orange plus 1 boxwood	0	Good	81 plus 5
	8	2 Rough lemon[a]	0	Good	76.0
Citrus soil with R. similis					
5)	6	3 Rough lemon	0	Poor	4.7
	6	3 " "	0	Poor	23.1
	6	3 " "	0	Poor	35.4
	6	3 boxwood	1326	Fair	16.6
6)	6	3 Rough lemon	0	Poor	10.0
	6	3 " "	0	Fair	5.3
	6	3 " "	7	Poor	27.4
	6	3 boxwood	1860	Good	12.5
7)	6	3 Rough lemon	0	Poor	8.7
	6	3 " "	19	Poor	6.4
	6	3 " "	0	Poor	27.2
	6	3 boxwood	2762	Good	18.0
Control (same soil steam-sterilized)					
8)	6	3 Rough lemon	0	Good	97.4
	6	3 " "	0	Good	117.7
	6	3 " "	0	Good	104.3
	6	3 boxwood	0	Good	21.3

[a] One Rough lemon plant had died.

A similar experiment was conducted with burrowing nematodes from banana. Twenty corn seedlings were inoculated; all 20 became infected and the recovered burrowing nematodes readily reinfected banana and corn.

The data contained in Table 3 were obtained from Rough lemon and sour orange seedlings and boxwood plants grown in soil from a commercial citrus grove heavily infested with burrowing nematodes. The experiment was composed of 4 groups of four 8-inch pots filled with the infested soil, one group of four pots having been steam-sterilized and used as a control. Three plants were planted in each pot. The roots and surrounding soil were examined for burrowing nematodes after 5 and 8 months. The roots were weighed and their condition recorded.

The experiment was repeated 6 months later.

It should be pointed out that increased soil fertility might, at least in part, account for the better root systems of the plants grown in the steam-sterilized soil. It is also interesting to note that very few burrowing nematodes were recovered from the badly damaged roots of plants grown in non-sterilized soil. The inoculated boxwood plants supported in most cases a heavy population of burrowing nematodes, apparently without much reduction in root weight.

SUMMARY OF RESULTS AND DISCUSSION

1) Inoculations of Rough lemon seedlings with burrowing nematodes from boxwood, calathea, ginger lily, banana, pothos and citrus were for the most part unsuccessful.

2) Inoculations of boxwood, calathea, ginger lily, banana and pothos with burrowing nematodes obtained from these hosts and citrus were successful.

3) Burrowing nematodes from citrus readily infected tomato and corn. However, re-inoculations of citrus (Rough lemon seedlings) with these populations from corn and tomato were not successful in 9 out of 10 cases. Corn and tomato could be reinfected at will.

4) Burrowing nematodes from banana readily infected corn. These populations on corn readily reinfected banana as well as corn.

5) Citrus should be called a relatively "poor host" for the burrowing nematode, since citrus was hard to infect and the rate of reproduction was less than on boxwood, calathea, ginger lily, banana, pothos, corn and tomato. Being a "poor host", however, might very well explain why citrus generally suffers more.

Literature Cited

1. BIRCHFIELD, W. 1956. New and suspected host-plants of the burrowing nematode, Radopholus similis (Cobb) Thorne. Plant Dis. Reptr. 40: 866-868.
2. BROOKS, T. L. 1954. The host range of the burrowing nematode, internationally and in Florida. Proc. Florida Hort. Soc. 67: 81-83.
3. BROOKS, T. L. 1955. Additional hosts of the burrowing nematode. Plant Dis. Reptr. 39: 309.
4. CHRISTIE, J. R., and V. G. PERRY. 1951. Removing nematodes from soil. Proc. Helm. Soc. Wash. 18: 106-108.
5. DuCHARME, E. P., and W. BIRCHFIELD. 1956. Physiologic races of the burrowing nematode. Phytopathology 46: 615-616.
6. FEDER, W. A., and J. FELDMESSER. 1957. Additions to the host list of Radopholus similis, the burrowing nematode. Plant Dis. Reptr. 14: 33.
7. GODFREY, G. H. 1931. The host plants of the "burrowing" nematode, Tylenchus similis. Phytopathology 21: 315-322.
8. YOUNG, T. W. 1954. An incubation method for collecting migratory endo-parasitic nematodes. Plant Dis. Reptr. 38: 794-795.

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THE EFFECTS OF AERATION AND TEMPERATURE ON THE EMERGENCE OF SPECIES OF PRATYLENCHUS FROM ROOTS[1]

Richard A. Chapman

Various techniques have been used to obtain nematodes of the genus Pratylenchus from roots of plants. Perhaps the simplest is to place infected roots in a vessel containing water and collect the nematodes that move out into the water. The vessels most frequently used have been Petri dishes and Baermann funnels. This technique is quite practical for qualitative work but is severely restricted for quantitative work because of the limited weights of roots that can be used in a vessel of reasonable size.

EFFECT ON NEMATODE YIELD OF RATIO BETWEEN SAMPLE SIZE AND SURFACE AREA

While using the Baermann funnel technique in attempting to determine the number of Pratylenchus species in roots of corn it soon became apparent that with a funnel 12.5 cm in diameter the yield of nematodes decreased sharply when more than 3 to 4 gm of roots were placed in it. In Table 1 are data from an experiment in which various amounts of corn roots were placed in Baermann funnels. The roots were washed and chopped into 1/2- to 1-inch long pieces. The pieces were thoroughly mixed before the samples were weighed. There were two replicates of the 12.5-cm and one of the 8.5-cm funnels. Samples were drawn from the funnels and nematodes counted at the times indicated (Table 1).

These results, expressed as the number of grams of roots per square centimeter of the exposed surface of the water in the funnels, indicate that the sharp decrease in yield occurred at 0.033 to 0.066 gm per sq. cm in the 12.5-cm funnels and at 0.025 to 0.049 gm per sq. cm in the 8.5-cm funnels. These two points are essentially the same.

When 90-mm Petri dishes are used it has been observed that from 1 to 2 grams is the maximum amount of roots that can be placed in them without a sharp decrease in the yield of nematodes. In this case the sharp decrease occurs at 0.031 to 0.063 gm per sq. cm of surface area. This point is in agreement with the results from the experiment with the Baermann funnels.

Putrefaction is the obvious development in the larger samples. Fungi and bacteria develop rapidly and saprophagic nematodes frequently occur in large numbers. The few parasitic nematodes that do emerge from the roots are usually immobile, but become active when placed in fresh water. All this suggests that aeration, meaning probably oxygen supply, is an important factor in the emergence of these nematodes from roots. The importance of aeration is compounded by the long intervals of time that roots must be kept in order to obtain maximum yields.

Young[2] developed an incubation method for obtaining nematodes from roots that is a decided improvement over the Baermann funnel technique and permits the use of larger root samples. It consists of placing moistened roots in a closed container that serves as a moist chamber. This method provides considerably more aeration of the roots than does the Baermann funnel method, but the size of the sample is limited by the volume of the container. Again, too large a root sample putrefies.

EXPERIMENTAL INVESTIGATION OF AERATION METHODS

The effect of aeration, and incidentally temperature, was investigated in several ways. The roots of various kinds of plants growing in a greenhouse in soil infested with species of Pratylenchus were used. When entire root systems were used from plants growing in different pots, the root systems were allotted to the treatments in such a manner that each treatment contained roots having similar opportunities for infection. When chopped roots were used several root systems were washed and chopped into pieces 1/2- to 1-inch long. The pieces were roiled and mixed in a bucket of water and then drained and blotted. Aliquots

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published with the approval of the Director.

[2] Young, T. W. 1954. An incubation method for collecting migratory endoparasitic nematodes. Plant Dis. Reptr. 38: 794-795.

Table 1. Yield of Pratylenchus sp. from different amounts of corn roots in Baermann funnels after indicated time in days.

Funnel diameter (centimeters)	Root weight (grams)	Nematode yield (Number per gram of roots) Time in days 2	5	7	Total
12.5	1	20	92	58	170
	2	19	68	68	155
	4	28	66	29	123
	8	7	8	11	26
8.5	0.7	103	63	27	193
	1.4	96	93	55	244
	2.8	7	19	2	28
	5.6	7	1	2	10

Table 2. Emergence of Pratylenchus sp. from aerated (shaken) and non-aerated (quiet) strawberry roots at different temperatures after indicated number of days.

Temperature (°C) and treatment	Root weight (grams)	Nematode emergence (Number per gram of roots) Time in days 1	3	6	13	Total
43° Quiet	1	7	0	0	0	7
	2	7	0	0	0	7
	4	17	0	0	0	17
	8	2	0	0	0	2
35° Quiet	1	20	33	20	7	80
	2	3	3	3	0	9
	4	10	0	0	0	10
	8	6	1	0	1	8
28° Quiet	1	27	27	20	20	94
	2	7	3	7	3	20
	4	7	3	5	2	17
	8	3	1	1	0	5
21° Quiet	1	7	2	4	7	20
	2	7	8	9	10	34
	4	6	1	2	1	10
	8	1	1	1	0	3
21° Shaken	1	20	13	20	33	86
	2	10	23	27	40	100
	4	22	27	17	57	123
	8	19	13	17	33	82

Table 3. Effect of aeration[a] on the emergence of Pratylenchus penetrans from corn roots.

Treatment of sample	Root weight (grams)	Nematode emergence (Number per gram of roots) Time in days 2	4	6	8	11	15	19	Total
Quiet[a]	1	53	33	20	0	7	13	0	126
	2	13	17	7	10	3	10	7	67
	4	10	3	2	3	2	0	0	20
	8	7	3	1	1	1	1	0	14
Shaken[b]	1	53	27	7	13	7	7	0	114
	2	67	53	50	20	7	13	0	210
	4	55	65	23	28	13	8	0	192
	8	49	67	26	23	9	8	6	188
Jars[c]	-	50	32	29	15	18	16	13	173

[a] Not aerated: samples in flasks not shaken. [b, c] Aerated: [b] in shaken flasks; [c] root system hung in jars.

Table 4. Emergence of Pratylenchus penetrans from corn roots in jars and shaken flasks.

Treatment	Nematode emergence (Number per gram of roots) Time in days 4	7	10	13	17	Total
Shaken	1662	833	698	215	112	3520
Hung in jars	693	386	444	172	143	1838

Table 5. Emergence of Pratylenchus penetrans and Pratylenchus scribneri from corn roots in non-aerated jars and jars aerated by bubbling air.

Aerated	Weight of roots in jars (grams)	Nematode emergence (Number per gram of roots) Time in days 3	5	6	9	12	15	Total
Yes[a]	7 & 8	1990	---	3696	2787	1735	885	11,093
No	9 & 15	756	---	1901	1659	1123	533	5,972
Yes[b]	0.5-2.8	----	454	----	297	----	---	751
No	0.9-2.0	----	390	----	208	----	---	598

[a] P. penetrans; [b] P. scribneri.

Table 6. Emergence of species of Pratylenchus from sprayed roots and roots in jars.

Treatment	Nematode emergence (number per gram of roots) Time in days										
	2	3	4	6	7	9	10	11	12	14	Total
Sprayed[a]	----	---	-----	89	---	80	----	----	---	----	169
Jars	----	---	-----	30	---	94	----	----	---	----	124
Sprayed[b]	----	---	-----	----	158	--	----	----	---	85	243
Jars	----	---	-----	----	44	--	----	----	---	43	87
Sprayed[c]	----	---	-----	6702	---	--	-----	1180	---	----	7882
Jars	----	---	-----	3879	---	--	----	4281	---	----	8160
Sprayed[c]	2219	718	671	736	---	--	638	----	792	----	5774
Jars	1115	719	1005	924	---	--	1134	----	473	----	5370

[a] P. scribneri in soybean roots; [b] P. scribneri in corn roots; [c] P. penetrans in corn roots.

Table 7. Yield of nematodes from entire root systems in jars after different periods of time.

Time in days	P. penetrans			P. scribneri		
	Alfalfa	Red Clover	Corn	Corn	Soybeans	Tomatoes
3	75	598	62	68	141	56
5	125	414	57	---	---	----
7	---	---	---	135	192	115
9	110	448	144	---	---	----
11	122	506	238	---	---	----
12	---	---	---	137	145	125
14	94	241	182	138	120	113
16	56	126	117	65	20	47
18	78	149	87	----	---	----
20	53	80	61	---	---	----
25	94	57	30	---	---	----
29	69	11	18	---	---	----
Total	876	2630	996	543	618	456

were weighed from the total mass of root pieces. This method of mixing provides more uniform aliquots than dry mixing. All weights are of washed and blotted roots.

Aeration was accomplished by several means. In one roots were placed in water contained in Erlenmeyer flasks that were shaken on a rotary shaker. In another air was bubbled through approximately an inch of water on the bottoms of fruit jars. In a third root systems were suspended in a mist produced by atomizers and the run-off and nematodes were collected through funnels in small jars. Quart fruit jars with the lids closed tightly but not sealed were used for the incubation (Young) technique.

All yield data are expressed as the number of nematodes per gram of washed, blotted roots and are the means of at least two, and in most cases three or more, replicates. Nematode counts were made at the times indicated by counting the number of nematodes in 5 percent of the area of a container.

Aeration by Shaking

The data in Table 2 were obtained from an experiment in which chopped strawberry roots infected with Pratylenchus sp. were placed in shaken and non-shaken flasks at different temperatures. The roots were placed in 75 ml of water in 125-ml flasks. This amount of water just covered the 8-gm samples.

The yield of nematodes from the 1-gm samples in the quiet flasks increased as the temperature increased to 35° C. This was not true of the heavier samples. On the other hand the yields from samples of all weights in the shaken flasks at the lowest temperature were fairly uniform and were comparable to the highest obtained. With the exception of the 1-gm samples, the material in the quiet flasks was soon contaminated with fungi, bacteria, and other microorganisms, the amount of contamination increasing with the weight of roots and increase in temperature. There was little growth of microorganisms in any of the shaken flasks.

These results indicate that aeration has a greater effect than temperature on the emergence of these nematodes from roots.

The data from a similar experiment with corn roots infected with Pratylenchus penetrans (Cobb, 1917) Sher & Allen, 1953 are presented in Table 3. As before, chopped roots were placed in flasks and the root systems of ten plants were each hung in a fruit jar and kept under the same conditions as the flasks. The weights of roots in the jars ranged from 2.4 to 9.1 gm. The temperature was 30° to 32° C.

These results again show the effect of aeration, accomplished here by shaking the roots in water or suspending them in jars, in increasing the emergence of these nematodes from roots.

The data in Table 4 are from a comparison of the yields of nematodes from corn roots in jars and shaken flasks. Entire root systems were suspended individually in quart jars or placed in 300-ml Erlenmeyer flasks containing sufficient water to cover them. The weights of roots in the jars ranged from 9 to 11 gm and those in the flasks from 10 to 15 gm. The roots were infected with Pratylenchus penetrans. The temperature was 30° to 32° C.

These results indicate that shaking is a more efficient means of aeration than incubation in jars.

Aeration by Bubbling Air

In Table 5 are presented the data from two experiments in which corn root systems were suspended individually in quart jars and one-half the jars were aerated by bubbling air through them. The temperature was 25° C.

The first comparison is between the means of two replicates of roots infected with Pratylenchus penetrans. The weights of roots were 7 and 8 gm in the aerated jars and 9 and 15 gm in the non-aerated jars. The second comparison is between the means of six replicates of roots infected with P. scribneri Steiner, 1943. The weights of roots in these jars ranged from 0.5 to 2.8 gm in the aerated jars and from 0.9 to 2.0 gm in the non-aerated jars.

These results indicate the relation of size of root sample to the amount of increase in emergence resulting from aeration. The increase in yield of nematodes resulting from aeration was 86 percent for the heavier root samples and 26 percent for the lighter ones. The data in Table 4 are from root samples comparable to the heavier samples here and the increase in yield resulting from aeration was 92 percent. The differences would be expected because in a given volume conditions tending toward anaerobiosis should develop more rapidly with larger than with smaller root samples. The lids on the jars used herein were not airtight, but exchange of gases with the outside air was considerably reduced.

It appears that the maximum quantity of roots that may be used in a quart jar without loss in yield of nematodes is approximately 10 gm.

Aeration by Spraying

Data of several trials comparing the yields of nematodes from sprayed roots and roots in jars are contained in Table 6. The temperature of these experiments was 25° C.

Spraying roots did not provide as great an increase in yield of nematodes over that obtained in jars as the other methods tried. The experiment with soybean roots consisted of four replicates with root weights ranging from 2.3 to 3.0 gm in the spray and from 2.8 to 4.2 gm in the jars. These were small amounts of roots and a pronounced effect would not be expected. The experiment with corn roots infected with Pratylenchus scribneri in which there was a 179 percent increase in yield due to spraying consisted of four replicates with root weights ranging from 18 to 33 gm in the spray and from 15 to 30 gm in the jars. These were large amounts of roots and a pronounced effect would be expected.

The first experiment with corn roots infected with Pratylenchus penetrans consisted of five replicates with root weights ranging from 2.9 to 5.2 gm in the spray and from 2.9 to 8.2 gm in the jars. A pronounced effect would not be expected here and the yield from the roots in jars was greater than that from the sprayed roots. The second experiment with corn roots infected with P. penetrans consisted of two replicates with root weights of 10 to 14 gm in the spray and 7 and 9 gm in the jars. A little more effect than was obtained might be expected in this experiment. In this last experiment, as in many of the others, the frequent counts necessitated frequent changes of water or washing of the roots in the non-aerated treatments and provided more aeration than would have occurred had the preparations remained quiescent during the experiments. Otherwise the differences in favor of the aerated situations might have been greater.

Effect of Aeration on Length of Time Required for Maximum Yield

The frequent counts were made in order to determine if there was a more consistent or more rapid rate of emergence in one situation than the other. One of the problems in obtaining quantitative data is determination of the length of time that roots must be kept to obtain reliable data. The data in Table 7 are representative of many obtained from jars and show the irregular rate of emergence of the nematodes from roots.

There is no point in time at which a reliable percentage of the total yield is obtained. Samples have to be kept until they show definite signs of being exhausted of nematodes. This amounts to a considerable length of time in most cases. None of the means of aeration used here provides any improvement in this situation. Aeration increases the total number of nematodes obtained but does not consistently alter the rate or pattern of emergence.

DISCUSSION

Because of the long periods of time that samplesof roots must be kept before they are exhausted of nematodes, some means of aeration is essential if frequent changes of water or washings are to be avoided. Of the methods tried here, passing air through jars and agitation on a shaker were the most effective. The latter has a disadvantage in that the considerable amount of cellular debris accumulating in the flasks may make counting difficult if measures are not taken to get rid of it. The collections of nematodes that were most free of foreign material were obtained from the sprayed roots. Furthermore, the nematodes from sprayed roots continually move down into the receiver and no washing of the roots is necessary to make a collection. Whereas from one-fourth to one-half of the nematodes in a given collection from roots in jars are among the roots and have to be washed out, less than 5 percent of a collection have been found among sprayed roots. The development of saprophagic nematodes was much greater in the jars than in the other aerated preparations.

REACTION OF OATS TO POWDERY MILDEW

H. H. Luke, W. H. Chapman, and A. T. Wallace[1]

Powdery mildew (Erysiphe graminis var. avenae) occurs throughout most areas of the world where oats are grown (1, 3, 5, 7, 11, 12). This pathogen is sensitive to certain environmental conditions (1, 8) and seldom develops into a serious disease; nevertheless, it has been named as one of the most serious diseases of oats in Britain (4). It is not common in the major oat-growing areas of the United States (2, 10) but is usually present in the southern winter oat area, where it normally causes little damage.

The spring of 1956 was dry and cool in north Florida and a severe epiphytotic of oat mildew occurred in the nursery at Quincy. This epiphytotic extended over a 7-week period during which time it was possible to evaluate a large number of varieties and selections for their reaction to this disease. Determination of host reaction was initiated on March 26, when most of the material was in the early boot stage. At this time, the disease had been prevalent for 5 weeks; therefore, it is unlikely that any of the material evaluated escaped infection.

Disease reactions were determined using the host class reaction method developed by Mains (6). This system follows:

Symbol	Host reaction classes	Types of infection
0	Highly resistant	No apparent development of mildew, occasional development of very slight amount of mycelium and haustoria usually to be noted microscopically, only by small chlorotic flecks.
1	Very resistant	Slight development of mycelium with little or no sporulation.
2	Moderately resistant	Moderate development of mycelium, with light sporulation.
3	Moderately susceptible	Moderate to heavy development of mycelium and moderate sporulation.
4	Very susceptible	Heavy development of mycelium and abundant sporulation.

Using this method, reactions were determined for a total of 250 varieties and selections. This material, most of which was replicated several times, represented the Uniform Southern Winter Oat Nursery, Uniform Central Nursery, Preliminary Yield Test, Uniform Rust Nursery, and a Quincy and Beltsville Breeding Series.

The primary objective of this note is to list resistant types adapted to the Southeast. Therefore, it did not seem necessary to list the reactions of the 250 varieties and selections observed; consequently, only those showing a high degree of resistance are presented in Table 1. When the reactions of this material were studied, several points worthy of note were observed. These points were : 1) All Red Rustproof types proved to be highly resistant; 2) Victorgrain and selections from crosses involving this variety made up 25 percent of the highly resistant types, suggesting that Victorgrain carries one or more genetic factors for resistance; 3) Selections from crosses carrying Clinton[2]-Santa Fe as a parent had a tendency to be highly susceptible. Of the 250 varieties and selections observed, all that carried Clinton[2]-Santa Fe as one of the parents were quite susceptible. Mildew reactions of selections from 10 widely different Clinton[2]-Santa Fe crosses are found in Table 1 (see entries 23 through 31).

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Table 1. Reaction of oat varieties and selections to powdery mildew.

Entry No.	Variety or pedigree of parents	C. I. or AB[b] No.	Mildew[a] reaction
1	Appler	1815	0
2	(Arl. Delair) x Trisp. C. I. 6908	7155	1
3	(Arl. Delair) x Trisp. C. I. 6908	7156	1
4	Victorgrain x (Bonda-H. J. -S. Fe)	7158	1
5	Victorgrain HVR	6977	0
6	Victorgrain 48-95	7125	1
7	Red Rustproof 14	4876	1
8	(Arl. -Delair) x Trisp. Coker 55-5	6987	1
9	0-200-10 x Southland 1954	AB110	1
10	48-8 x Southland 1954	AB206	1
11	New Nortex x Trelle Dwarf	6729	0
12	Mulga-Sel Rehovoth[c]	AB114	0
13	(C. I. 5915 x C. I. 6574) x (Vict. -H-B)	AB157	1
14	(C. I. 5915 x C. I. 6574) x (Vict. -H-B)	AB158	1
15	(C. I. 5915 x C. I. 6574) x (Vict. -H-B)	AB159	1
16	Victorgrain x (Bonda x H. J. x S. Fe)	-	0
17	Victorgrain x Fulwood x C. I. 6671	-	1
18	Victorgrain x (B. R. -H. J. x Landh.)	-	1
19	Saia	4639	1
20	Landhafer	3522	1
21	New Nortex x Landhafer	6998	1
22	(H. J. x (Lee x Vict. x Ful.)-Bond. Anthony) x Landhafer	7152	1
23	Trisp. x (Cl^2-S. Fe)	6978	3
24	Letoria x (Cl^2-S. Fe)	7016	4
25	H. J. (Atl. x Cl^2-S. Fe)	7157	3
26	Atlantic (Cl^2-S. Fe)	6985	4
27	Wintok (Cl^2-S. Fe)	6740	3
28	(C. I. 4658 x Cl^2-S. Fe) x Bonda x (H. J. x S. Fe)	7137	3
29	Winter turf x (Cl^2-S. Fe)	7139	4
30	(Trisp. x Cl^2 x S. Fe) x Atl. x Cl^2-S. Fe	-	4
31	(RR x V. R. : C. I. 3717 x Sib. C. I. 4316) x Cl^2-S. Fe	-	4

[a] For disease reaction see text.

[b] AB number is a Quincy selection number grown at Aberdeen, Idaho.

[c] The Mulga-Sel Rehovoth was obtained by Mr. W. H. Chapman from Dr. I. Wahl of the Hebrew University, Jerusalem.

DISCUSSION

Observations on mildew reactions contained herein agree somewhat with previous reports (2, 9, 10). It is noteworthy to point out that observations from Florida are in closer agreement with those from Arkansas (9) than with those from either Indiana or Iowa (10, 2). The difference, as suggested by Rosen (9), may be due to the fact that results from Arkansas and Florida were based wholly on field reactions of plants in various stages of maturity, while reports from Iowa and Indiana were based on seedling reactions under greenhouse conditions. Even though minor differences in resistance occur from location to location, recent observations from the United States (2, 9, 10) are somewhat in agreement. Thus, it appears that physiological races of this organism are not as yet common in North America. A current report from England (4) however, indicated the prevalence of physiological races in certain areas of Britain.

During peak infection, it appeared that grain yields in the Quincy nursery would be seriously reduced; however, when yield was compared with mildew reaction, an unexpected observation was made; that is, there appeared to be no relationship between susceptibility and grain yield. Of the top 10 yielders in the Uniform Southern Winter Oat Experiment, six were completely sus-

ceptible, and in a Quincy Preliminary Yield Test, nine of the top ten were susceptible. In a Quincy Breeding Series, seven of the top ten were susceptible. Past performance of some of the resistant and susceptible varieties did not depart greatly from their 1956 yield. It should be pointed out that hot weather occurred and mildew virtually disappeared when most of the material was in the late boot or early heading stages. Therefore, these observations suggest that oat mildew does not severely reduce grain yield when disease development is arrested prior to the early heading stages of the host. However, forage yield was severely affected by the disease. Even though no data are available, there was an estimated 40 to 50 percent reduction in forage yield.

Literature Cited

1. CHEREWICK, W. J. 1944. Studies on the biology of Erysiphe graminis DC. Canad. Jour. Res. 22: C, 52-86.
2. FINKNER, R.E., H.C. MURPHY, and R. E. ATKINS. 1953. Reaction of oat varieties to powdery mildew. Agron. Jour. 45: 92-95.
3. HOMMA, Y. 1937. Erysiphaceae of Japan. (Abst.) Rev. Appl. Mycol. 16: 632-633.
4. JONES, E. T., and D. J. GRIFFITHS. 1952. Varietal resistance and susceptibility of oats to powdery mildew (Erysiphe graminis). Trans. British. Mycol. Society 35: 71-80.
5. MACFARLAN, J., and J. GRAINGER. 1947. Corn mildew on oats. Scot. Jour. Agr. 26: 211-215.
6. MAINS, E. B. 1926. Rye resistant to leaf rust, stem rust, and powdery mildew. Jour. Agr. Res. 32: 201-221.
7. MARCHAL, E. 1902. De la spécialisation du parasitisme chez l'Erysiphe graminis. C. R. Acad. Sci. Paris, 135: 210-212.
8. MOORE, W. C. 1945. Cereal diseases -- their recognition and control. Bull. Minist. Agr. Fish. 129: 1-42.
9. ROSEN, H. R. 1957. Epidemics of powdery mildews in Arkansas in 1956 with special reference to powdery mildew on winter oats. Plant Dis. Reptr. 41: 330-336.
10. SCHAFER, J. F., R. M. CALDWELL, L. E. COMPTON, and F. L. PATTERSON. 1953. Reaction of oat varieties and selections to powdery mildew at Lafayette, Indiana. Plant Dis. Reptr. 37: 306-309.
11. VALLEGA, J., and E. A. FAVRET. 1947. Royas y otros parasitos de los cereales en los valles Andino-Patagónicos. Rev. Invest. Agr. B. Aires. 1: 269-278.
12. WESTON, W. A. R. DILLON 1945. Powdery mildew of cereals. Jour. Minist. Agr. Great Britain 52: 522-524.

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OVERWINTERING AND SPREAD OF WHEAT POWDERY MILDEW IN 1957

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Summary

Powdery mildew was unusually injurious to winter wheat in the Southeast during 1956-57. A test plot at Beltsville, Maryland was examined throughout the growing season with regard to the disease cycle. Severe natural infection occurred on the test plants soon after their emergence in October. A small percentage of conidia remained viable during the winter, demonstrating overwintering in the vegetative stage. Overwintering lesions also served as centers of infection when favorable conditions returned in the spring. Regional collections revealed the presence of races with genes for virulence against the varieties Chul and Normandie. The mildew racial situation is discussed with regard to its effect on breeding programs in the region.

INTRODUCTION

Winter wheat in the southeastern United States was severely damaged during the last growing season by powdery mildew, caused by Erysiphe graminis DC. f. sp. tritici Em. Marchal. Throughout the area as a whole, and in particular the coastal plain, the attack by powdery mildew was one of the most severe in recent years. The heavy infection, which often spread up to the flag leaves, undoubtedly caused considerable reductions in yields (10).

This unusual incidence of mildew was due to a favorable combination of the three requirements usually considered necessary for severe outbreaks of a disease: The presence of susceptible hosts, an abundance of inoculum, and favorable conditions for infection and spread. The lack of compatible hosts was not a limiting factor, since the varieties of wheat grown in this region do not possess high levels of resistance to the prevalent races of mildew. An abundance of inoculum was assured as the mildew organism became well-established in the fall of 1956 and overwintered satisfactorily. Spring conditions favored secondary spread and mildew became exceptionally destructive as the crop matured.

Several European investigators have noted that widespread infection during the fall increases the probability of severe outbreaks of mildew the following spring (7, 12). The exact mode of overwintering of this organism has been the subject of much controversy. Many earlier workers were of the opinion that cleistothecia were the overwintering bodies (3, 4, 5). Other investigators, however, reported that the organism overwintered either in the conidial stage (1, 8, 9, 11, 18) or as mycelial mats (2, 6). Different climatic conditions may account for some discrepancies between these reports; however, most workers now believe that the cleistothecia do not usually function in overwintering.

PROCEDURE AND RESULTS

None of the studies cited above dealt with conditions in the Middle Atlantic or southeastern United States; therefore, it was thought that observations on the mode of overwintering in this area would be desirable. The particularly heavy infection of wheat in the vicinity of Beltsville, Maryland offered an opportunity for a study of this type. A plot of Purplestraw wheat (C. I. 1915[2]) was examined periodically throughout the winter of 1956-57. The plants became naturally infected with mildew soon after their emergence in late October. By early December the plants were so heavily attacked that the entire plot had a yellowish cast. December was particularly warm in this area, and the mildew sporulated abundantly and continued to spread to new growth. This spread was checked by low temperatures early in January. The temperatures in January ranged from -3° to +63° F. February temperatures ranged from 20° to 69°. Throughout January and February no new infections were observed. The mildew lesions were compressed and tan in color, and gave no evidence of sporulation.

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[2] C. I. refers to accession numbers of Cereal Crops Research Branch, Crops Research Division.

A clump of plants was removed from the plot and taken to the laboratory on the morning of February 12, following a low of 20° F the previous night. The mildew lesions were examined microscopically and short chains of conidia were observed. Approximately 300 conidia from three different lesions were plated out on water agar at room temperature. Eleven percent of the conidia had germinated after 24 hours and produced germ tubes at least half as long as the conidia themselves.

The infected plants from the field were used immediately to inoculate susceptible plants of the Little Club (C. I. 4066) wheat variety. Abundant infection was observed on the inoculated plants within 7 days. The culture was tested on the differential varieties in order to identify its pathogenic type, and gave the following results:

Variety	C. I. No.	Reaction[3]
Axminster	8195	0
Chul	2227	0
Hope	8178	3-4
Huron RL20	12663	4
Norka	4377	0
Normandie	12747	0
Ulka	11478	4

This race has been quite common in the Southeast for some time, and also was the race most frequently collected this year.

No new infections were observed in the test plot until the second week in March. From this time on the mildew spread rapidly over the new growth. Ninety percent of the surface of the lower leaves was covered with mycelium of the fungus when the plants reached maturity.

DISCUSSION

The results obtained demonstrated that the mildew organism overwinters in the vegetative stage in this region, and that a few viable conidia may be present throughout the winter. Widespread infection of young plants in the fall is therefore particularly significant, since these plants would serve as reservoirs of inoculum during the early spring.

The epiphytotic of mildew during the growing season of 1956-57 resulted from unusually favorable conditions for the development and spread of the pathogen, rather than from any shift in races of the mildew organism. Some outbreaks of mildew in the past have been attributed primarily to the appearance of new races that attacked previously resistant varieties (17). This year, however, the race collected most frequently was one that has been very common in the Southeast for some time (13). Since none of the commercial varieties of wheat grown in this area are highly resistant to the prevalent races of mildew, there is no selection pressure on the organism favoring the development of new races.

Two unusual collections were made this year. Conidial cultures from Charleston, South Carolina and Kearneysville, West Virginia were found to contain racial mixtures. In each case the primary race was similar to that observed in the Beltsville plots; however, a few pustules of different races also were observed. The Charleston variant was found to be virulent on the Chul (C. I. 2227) variety, and Normandie (C. I. 12747) was susceptible to the Kearneysville collection. These two races have been collected previously, but not in these specific areas. The varieties Chul and Normandie, which are used as differentials for races of mildew, are usually quite resistant to this pathogen. Their susceptibility to naturally occurring races of mildew indicates that a wide range of virulent types are present in nature, as has been demonstrated by work involving the sexual stage of the organism (13). In the face of such a diversity of pathogenic types, the danger of basing the resistance of future commercial varieties upon one factor for resistance is obvious.

Several factors for resistance to mildew have been demonstrated (15, 16), and their relationship to factors for virulence in the pathogen is now being investigated (14). Utilization of these resistance factors in breeding, plus vigilant observation of the pathogen to detect shifts in the pathogenic races, are necessary steps in the development of a method of combating mildew in this region.

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[3] 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, and 4 = very susceptible.

Literature Cited

1. BROOKS, F.T. 1928. Plant diseases. Oxford Univ. Press. 386 p.
2. CHEREWICK, W.J. 1944. Studies on the biology of Erysiphe graminis DC. Canad. Jour. Res. Sect. C. 22: 52-86.
3. DASH, J.S. 1912-13. The powdery mildew. Ann. Rept. Quebec Soc. for the Protection of Plants from Insects and Fungous Diseases 5: 32-38.
4. DIMITRIOU, G. 1909-10. The mildew of cereals. Ann. Rept. Quebec Soc. for the Protection of Plants from Insects and Fungous Diseases 2: 16-19.
5. FOSTER, W.R., and A.W. HENRY. 1937. Overwintering of certain cereal pathogens in Alberta. Canad. Jour. Res., Sect. C. 15: 547-559.
6. GORLENKO, M.V. 1940. Neue Befunde über die biologie von Erysiphe graminis tritici March. Compt. rend. acad. sci. URSS (n.s.) 27: 866-870.
7. GORLENKO, M.V. 1942. Modes of hibernation of mildew (Erysiphe graminis D C.) on cereals. Compt. rend. acad. sci. URSS (n.s.) 35: 187-188.
8. HONECKER, L. 1936. Über den derzeitigen Stand und die Aussichten der Bekämpfung des Mehltaubefalles der Gerste durch Züchtung. Prakt. Bl. Pflanzenb. 13: 309-320.
9. MEHTA, K.C. 1930. Studies on the annual recurrence of "powdery mildews" of wheat and barley in India, I. Agr. Jour. India 25: 283-285.
10. MIDDLETON, G.K. 1947. Importance of mildew in the soft winter wheat area. Rept. of the tenth Eastern Soft Wheat Improvement Conf., Cincinnati, Ohio, pp. 12-13.
11. MONTEMARTINI, L. 1930. Note di fitopatologia. Riv. Pat. Veg. 20: 201-206.
12. PAPE, H., and B. RADEMACHER. 1934. Erfahrungen über Befall und Schaden durch den Getreidemehltau (Erysiphe graminis D C.) bei gleichzeitigen Anbau von Winter- und Sommergerste. Angew. Botan. 16: 225-250.
13. POWERS, H.R., Jr., and J.G. MOSEMAN. 1957. Pathogenic variability within cleistothecia of Erysiphe graminis. Phytopathology 47: 136-138.
14. POWERS, H.R., Jr., and W.J. SANDO. 1957. Genetics of host- parasite relationship in powdery mildew of wheat. Phytopathology (Abst.) 47: 453.
15. PUGSLEY, A.T., and M.V. CARTER. 1953. The resistance of twelve varieties of Triticum vulgare to Erysiphe graminis tritici. Austral. Jour. Biol. Sci. 6: 335-346.
16. RAY, D.A., T.T. HEBERT, and G.K. MIDDLETON. 1954. Inheritance of resistance to powdery mildew in wheat. Agron. Jour. 46: 379-383.
17. TAYLOR, J.W., H.A. RODENHISER, and B.B. BAYLES. 1949. Physiologic races of Erysiphe graminis tritici in the southeastern United States. Agron. Jour. 41: 134-135.
18. TURNER, D.M. 1956. Studies on cereal mildew in Britain. Brit. Mycol. Soc. Trans. 39: 495-506.

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PATHOGENICITY OF CERTAIN ISOLATES OF WHEAT STEM RUST TO DURUM WHEAT VARIETIES[1]

G. J. Green[2] and E. R. Kerber[3]

Summary

In the survey for physiologic races of wheat stem rust in Canada in 1956, some isolates were obtained which attacked seedlings of one or more of the new durum wheat varieties Ramsey, Towner, Yuma and Langdon more vigorously than other isolates. Infection studies with adult plants demonstrated that an isolate of race 15 was virulent to Langdon, moderately virulent to Yuma, and avirulent to Ramsey and Towner. An isolate of 15B-1 (Can.) possessed some virulence to Langdon and, to a lesser degree, to Yuma, but it could not attack Ramsey or Towner. A second isolate of race 15B-1 (Can.) was less virulent to Langdon and Yuma and could not attack Ramsey and Towner. An isolate of race 15B-4 (Can.) could not attack Langdon and Yuma but was virulent to Ramsey and Towner. Mindum was very susceptible to all four isolates, whereas, Golden Ball was susceptible only to race 15B-4 (Can.). These four isolates along with isolates of six other races could not attack seedlings of the varieties St. 464, C.I. 7790, C.I. 7794, C.I. 7871, C.I. 8150, C.I. 8154 and C.I. 8155.

INTRODUCTION

To offset the devastating effect of race 15B of stem rust (Puccinia graminis var. tritici) on the production of durum wheat in central North America, the varieties Langdon, Yuma, Ramsey and Towner were released for distribution to United States farmers in 1956. In 1957 Ramsey was licensed for distribution in Canada as well. In the survey for physiologic races of wheat stem rust in Canada in 1956, certain isolates of races 15 and 15B were found to have greater virulence on seedlings of one or more of these varieties than other isolates. Although the field resistance of these varieties has been reasonably satisfactory at Winnipeg, rather large pustules have been observed on them from time to time. Greenhouse trials with adult plants were carried out in the fall of 1956 to discover if the more virulent isolates of races 15 and 15B might be responsible for these large pustules.

ADULT PLANT REACTIONS

Seed of the varieties Mindum, Golden Ball, Langdon, Yuma, Ramsey and Towner was sown separately in 6-inch pots on August 10, 17, 24, and 31. Four plants were usually grown in each pot. The plants of Langdon and Yuma were inoculated on November 26 when the earliest sown plants were in the early mild stage and the last sown were in the flag leaf or boot stage. Ramsey and Towner were inoculated on November 26 and November 28 respectively, when the earliest sown plants were heading and the last sown were in the flag leaf stage. Mindum and Golden Ball were inoculated on November 26 and November 28 respectively, when the earliest sown plants were in the post-anthesis stage and the last sown were in the flag leaf or boot stage. The rust reaction of Langdon and Yuma was determined on December 17, of Mindum, Towner and Golden Ball on December 19, and of Ramsey on December 20. The reaction type of each variety was fairly uniform at each stage of plant development but plants inoculated just after heading were the most heavily infected. The reaction of each variety was established by the method already described[4]. The results of all replicates were included in the calculation of the numerical value representing the average reaction of

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[4] Green, G. J., and T. Johnson. 1955. Specificity in the effect of high temperature on the adult plant reaction of wheat varieties to races of stem rust. Can. J. Bot. 33: 107-201.

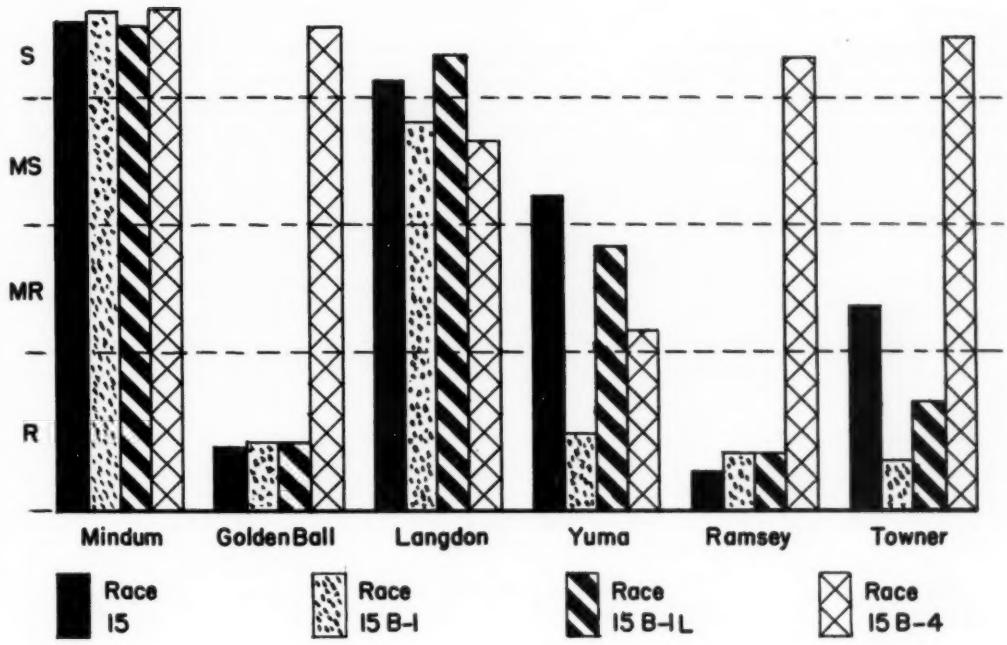

FIGURE 1. Adult plant reaction of durum wheat varieties to wheat stem rust isolates.

each variety.

The stem rust races selected were virulent to durum wheats. Race 15B-1 (Can.)[5] (No. 138[4, 5]) is the common type of 15B. It is not virulent on the varieties Golden Ball or Selkirk but it is extremely virulent on durum varieties such as Mindum, Stewart and Carleton. Race 15B-4 (Can.) (No. 139[4, 5]) also occurred widely in Western Canada in 1956. It is not virulent on Selkirk, but it is virulent on the durum variety Golden Ball, which has been used as a source of resistance to 15B, and on the other durum varieties susceptible to race 15B-1 (Can.). Race 15 (No. 10[4, 5]), a rare race isolated frum rust collections made in Eastern Canada in 1956, was selected because of its virulence on seedlings of Yuma and Langdon. Race 15B-1 (Can.) (No. A9[4, 5]) represents an uncommon strain of 15B which, on the basis of seedling reactions, was more virulent to Langdon and Yuma than most cultures of this race. This culture was isolated from rust collected on Langdon and the race is here temporarily designated 15B-1L (Can.).

The average greenhouse temperature from the date of inoculation to the date when the reactions were determined was 67.3° F. The average minimum daily temperature which occurred about midnight was 63.9°, and the average daily maximum temperature which occurred about noon was 74.6°. Natural light was supplemented by light from standard warm white fluorescent tubes from 5 p.m. to 10 p.m.

The adult plant reactions of six durum wheat varieties to these four stem rust isolates appear in Figure 1. The variety Mindum, as anticipated, was highly susceptible to the four isolates. Golden Ball was resistant to three races but was susceptible to race 15B-4 (Can.). The

[5] (Can.) Designates a line or subrace of rust identified by the reaction of supplementary host varieties in Canada.

Table 1. Seedling reactions of durum wheat varieties to stem rust races at Winnipeg, November and December, 1956.

Variety	Resistant	Moderately resistant	Moderately susceptible	Susceptible
Baladi 116	11-1, 15B-1[a], 29-2, 48A, 56, 147	15, 15B-4	15B-3	15B-1[b]
Baladi 122	29-2, 48A, 56	11-1, 15, 15B-1L, 147	15B-4	15B-1
Beloturka	15B-1L, 29-2, 48A, 56, 147	15, 15B-1, 15B-3	11-1, 15B-4	
Carleton	11-1, 29-2, 48A, 56		147	15, 15B-1, 15B-1L, 15B-3, 15B-4
Chapinge	15B-1L, 29-2, 48A, 56, 147	15, 15B-1, 15B-3	11-1, 15B-4	
Golden Ball		15, 15B-1, 15B-1L, 15B-3, 29-2, 56, 147		11-1, 15B-4, 48A
Iumillo	11-1, 15, 15B-1L, 29-2, 48A, 56, 147	15B-3, 15B-4*	15B-1	
Khapli	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56, 147			
Langdon	11-1, 29-2, 48A*, 56	15B-3, 147	15B-1, 15B-4	15, 15B-1L
Ramsey	15B-1, 15B-1L, 29-2, 48A, 56, 147	11-1, 15, 15B-3		15B-4
Towner	15B-1, 15B-1L, 29-2, 48A, 56, 147	15, 15B-3	11-1	15B-4
Yuma	11-1, 15B-1, 15B-3, 29-2, 48A, 56	15B-4, 147	15, 15B-1L	
Ld 368	11-1, 15, 15B-1, 15B-3, 15B-4*, 29-2, 48A, 56, 147	15B-1L		
St 464	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56, 147			
P.I. 94701		15, 15B1, 15B-1L, 15B-3, 29-2, 56, 147*	11-1	15B-4, 48A

[a]Race 15B-1 (Can.), Culture No. 138[4,5], referred to as the common type of 15B.
[b]Race 15B-1L (Can.), Culture No. 130[4,5], a strain of race 15B-1 (Can.) with virulence to seedlings of Langdon and Yuma.

Table 1. (Continued).

Variety	Resistant	Moderately resistant	Moderately susceptible	Susceptible
R.L. 1714	29-2, 56, 147	15, 15B-1, 15B-1L, 15B-3		11-1, 15B-4, 48A*
R.L. 3174.6	11-1, 15, 15B-1, 15B-1L, 15B-3, 29-2, 48A, 56, 147	15B-4		
R.L. 3206	29-2, 48A, 56, 147	15, 15B-1, 15B-1L, 15B-3		11-1, 15B-4
R.L. 3207	15B-1L, 56, 147*	11-1*, 15, 15B-1, 15B-3, 29-2*	15B-4*, 48A*	
R.L. 3211.5	11-1, 15B-3, 29-2, 48A, 56, 147	15, 15B-1, 15B-1L		15B-4
R.L. 3254	11-1, 15B-1, 15B-1L, 15B-3, 29-2*, 48A*, 56, 147	15	15B-4*	
C.I. 7790	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56			
C.I. 7794	11-1, 15, 15B-1, 15B-1L, 15B-3 15B-4, 29-2, 48A, 56, 147			
C.I. 7805	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56		147	
C.I. 7871	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56	147		
C.I. 8150	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56			
C.I. 8154	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56, 147*			
C.I. 8155	11-1, 15, 15B-1, 15B-1L, 15B-3, 15B-4, 29-2, 48A, 56, 147			

*Indicates the variety segregated to this race. Most plants were in the group indicated.
NOTE--"(Can.)" has been omitted following the race numbers to reduce the length of the table.

new variety Langdon was susceptible to races 15 and 15B-1L (Can.) and moderately susceptible to races 15B-1 (Can.) and 15B-4 (Can.). The variety Yuma, which inherited rust resistance from the same parent (Khapli Emmer) as Langdon, was more resistant than Langdon. Ramsey and Towner, similar varieties from the rust reaction standpoint, were resistant to all races except 15B-4 (Can.).

SEEDLING REACTIONS

The seedling reactions of a number of varieties to the four stem rust races already described and to six additional races appear in Table 1. The additional races were 11-1 (Can.) which is virulent to Golden Ball and some of its derivatives, 15B-3 (Can.) and 29-2 (Can.) which are virulent to Selkirk, 48A, 56, and 147. The varieties include those tested in the adult plant stage, some of their ancestors, and a number of other varieties that are promising as sources of resistance. The seedling reactions and adult plant reactions agree closely. Although Yuma is more resistant than Langdon, neither of these varieties appears to have inherited the full resistance of their common ancestor, Khapli. P.I. 94701 and Golden Ball have similar rust reactions. This is reflected in the susceptiblility of Ramsey and Towner, derived from P.I. 94701, and Golden Ball to race 15B-4 (Can.). Ramsey and Towner differ from Golden Ball in reaction to some other races, however. The varieties St. 464, C.I. 7790, C.I. 7794, C.I. 7871, C.I. 8150, C.I. 8154, and C.I. 8155 have seedling resistance to all of these races.

DISCUSSION

The moderate susceptibility of Langdon to the common races 15B-1 (Can.) and 15B-4 (Can.) in the adult plant stage was not expected because this variety had been resistant in field trials at Winnipeg. In 1956 only a trace of rust was found on it, although the infection type ranged from resistant to moderately susceptible. In earlier adult plant and seedling trials in the greenhouse Langdon was more resistant to race 15B-1 (Can.) and 15B-4 (Can.) than in this test. Apparently the resistance of Langdon is rather unstable. In the field it is usually effective against races which may attack the variety when it is grown in the greenhouse under conditions favorable to rust.

Race 15B-4 (Can.), which can attack Ramsey and Towner, comprised about 20 percent of the stem rust isolates in Canada in 1956. Should this race increase in prevalence these varieties would be threatened. Races 15 and 15B-1L (Can.) which are virulent to Langdon and less virulent to Yuma have been found rarely. They would not be expected to attack these varieties severely unless their prevalence increases. The susceptibility of Langdon in the greenhouse to two common races indicates that this variety may be attacked in the field by these races when conditions are especially favorable to rust development.

CANADA DEPARTMENT OF AGRICULTURE

PHYSIOLOGIC RACES OF PUCCINIA RUBIGO-VERA F. SP. TRITICI IN THE UNITED STATES IN 1956[1]

C. O. Johnston[2]

Summary

Twenty-three physiologic races of Puccinia rubigo-vera f. sp. tritici were isolated from 218 collections of leaf rust made in 22 States of the United States in 1956. Physiologic race 122 was the most abundant and widely distributed race, displacing race 5 which has been first in prevalence for many years. Race 5 was second in prevalence, followed in order by races 105, 15, 6, and 58. Races 11 and 1 were the most important ones in the northwestern area, although race 11 also was abundant in Texas. As usual, race 58 was the most abundant one in the area around the Great Lakes.

Cultures were obtained from 218 collections of the leaf rust of wheat made in various parts of the United States in 1956. Collections were from 23 States, representing five major wheat-growing areas. These yielded 674 isolates, among which 23 physiologic races were recognized. The races fall naturally into 11 unified races in which similar races are grouped together under unified numbers. The results obtained are presented in Table 1.

Race 122. This race is the most important constituent of UN 13. It was the most abundant and widely distributed race in 1956. For the first time it exceeded race 5 which had been the most prevalent race in the United States for many years (Fig. 1). The group of which it is the main constituent comprised more than one-fourth of all isolates in 1956. It was isolated in collections from all but four States and was important in all geographic areas except the northwestern.

Race 5 was second in importance and with the similar race 52 comprised 19.7 percent of all isolates. However, this group decreased greatly in prevalence in 1956. Race 5 was found in all but five States and was important in all parts of the United States except the northeastern and northwestern areas.

Group Race 6, of which race 105 is the most important constituent, was third in prevalence in 1956, although it was less prevalent than in 1955. This group of races is largely responsible for the heavy infections of leaf rust seen on Concho and Kenya Farmer in 1956.

Race 15, which is the main constituent of UN 2, was fourth in prevalence and was slightly more prevalent than in 1955. This race has been one of the more important ones in the United States for many years and must be considered in any program of breeding for leaf rust resistance.

Race 58 was abundant in the States bordering the Great Lakes and in the Ohio Valley. It also is sometimes abundant in the Southeastern States but was much less prevalent than usual in that area in 1956.

Race 11 and Race 1 were most abundant in Idaho, although race 11 also was abundant in Texas, apparently having come into that State from Mexico where it is the most abundant race.

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Table 1. Physiologic races of Puccinia rubigo-vera f. sp. tritici isolated from field collections of the leaf rust of wheat made in the United States in 1956.

Geographic and crop area, and State	Number of isolates for unified races and constituent physiologic races																										Total number		
	1	2		3		5		6				9					10		11	13			14	17			
	1	2	15	58	161	5	52	6	28	105	126	9	10	19	20	11	131	93	54	77	122	50	143	Isolates	Races	Collections
NORTHEASTERN, SOFT WINTER																										
Arkansas			2		1	1															2			6	4	2
Illinois						1															3			4	2	1
Indiana				2		2															2			6	3	2
Michigan			2	19				1		6			1	2				1			11			43	8	13
Missouri			4	2		2		2		8	1			3							9			31	8	9
New York		1	2	5																1	2			11	5	5
Ohio				2			2	4		3											14			25	5	6
SOUTHEASTERN, SOFT WINTER																										
Alabama			4	1		7	1																	13	4	5
Florida		1	12	2		3				3	1						1		4		9			36	9	12
Georgia		1		1		2				?									6	1	24			36	7	10
Louisiana						2																		2	1	1
Mississippi			5			1				1		1							2	1	21			32	7	9
North Carolina						8				4									1					13	3	4
South Carolina			19			24	2	1		4	1			1			1		2	1	14	1		71	12	19
Tennessee			1							1											2			4	3	1
Virginia			5			2	1	2		2			1				1		1		6			21	9	8
CENTRAL, HARD RED WINTER																										
Kansas		1	19	1		28	1	5		11	1			3			2				14			88	12	31
Oklahoma			3			4		8	3	3	1		1	3	1						4			31	10	9
Texas	1	1	17	1		10		11		7	2	1	5	11	1		9	1	2		4			84	16	28
NORTH CENTRAL, HARD RED SPRING																										
Minnesota			13	2		26		8		6	1	3		2			1				5			68	11	20
North Dakota			2					2																4	2	1
Wisconsin			7	2		2		1		7								1			8		1	31	9	9
NORTHWESTERN, SOFT WINTER																										
Idaho	3					1					1						7	1			1			14	6	4
TOTALS	4	5	117	40	1	126	7	45	3	67	9	5	8	25	2	22	3	3	21	4	155	1	1	674	23	218
Percent of total isolates	0.6	0.7	17.6	5.9	0.05	18.6	1.0	6.7	0.4	10.0	1.3	0.7	1.2	3.7	0.3	3.3	0.4	0.4	3.1	0.6	23.0	0.05	0.05			
Percent of total isolates for group	0.6		18.0		6.0		19.7			18.5				5.9			3.7		0.4		26.7		0.05 0.05			

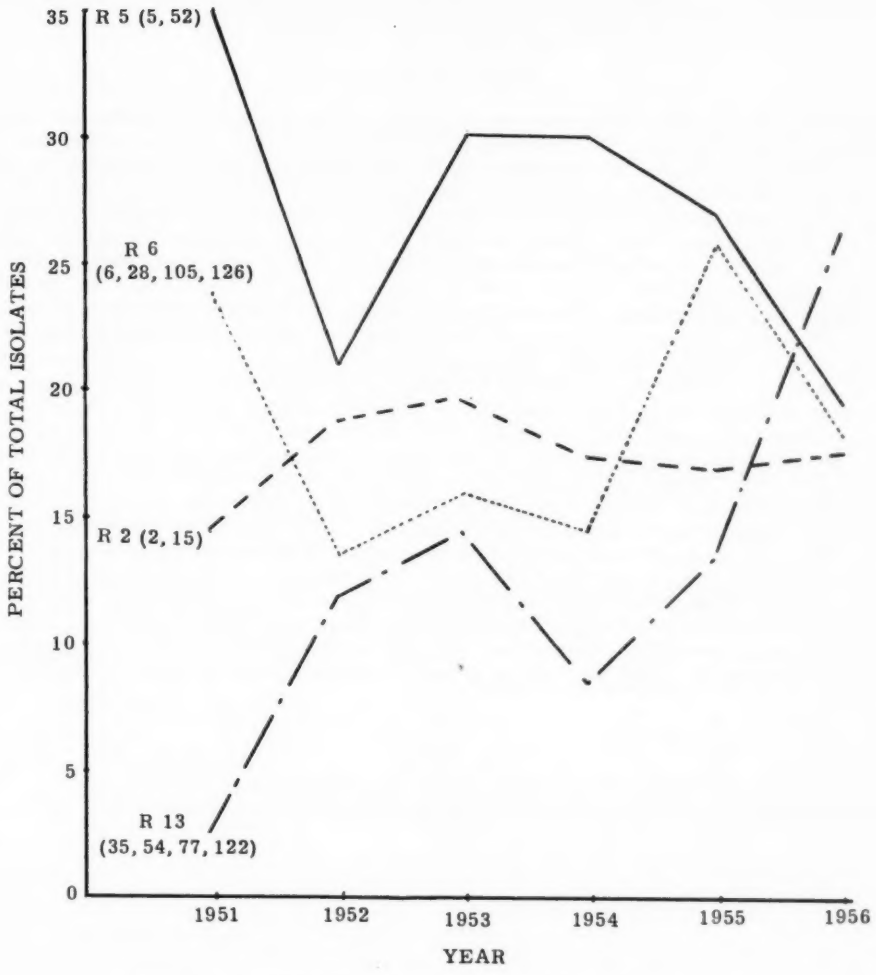

FIGURE 1. Prevalence of the four most important race groups of Puccinia rubigo-vera f. sp. tritici in the United States, 1951-1956.

Race 9 and the companion races of UN 9 continued to decline in prevalence. Collectively they represented only 5.9 percent of the total isolates in 1956, whereas they represented 31.0 percent of all isolates in 1946.

No new physiologic races were isolated from 1956 collections and no subraces with greater virulence than the races discussed above were noted. A few subraces of races 5 and 105 were isolated, using Westar selection of C. I. 13090 as a supplemental differential variety.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE,
UNITED STATES DEPARTMENT OF AGRICULTURE, IN COOPERATION WITH THE
KANSAS AGRICULTURAL EXPERIMENT STATION, MANHATTAN, KANSAS

PUCCINIA POLYSORA RUST ON FIELD CORN IN THE EVERGLADES OF FLORIDA[1]

Alice L. Robert and W. J. Wiser[2]

In May 1957, rust on field corn caused by Puccinia polysora was found for the first time in the Everglades area of Florida. The infection was observed in cooperative field corn plantings of the United States Department of Agriculture and the Everglades Experiment Station at Belle Glade, Florida. The first uredia of this rust were noted on May 14 when small groups of yellow pustules appeared sparingly on the upper surface of the leaves of some plants. By May 20 a moderate to heavy infection was apparent on some strains of corn. This development indicated that spore showers were deposited on the leaves around May 9 to 12. Spread of this rust after May 21 was moderate.

Specimens in the National Fungus Collections show that, in Florida, this rust was first collected in 1901 on Tripsacum dactyloides on Hog Island. In 1923, it was found in Seminole County near St. John's River, Sanford, on Erianthus divaricatus, and in the same area in 1924 on corn. In 1943, specimens were collected from late plantings of field corn near Quincy in Gadsden County and near Jay in Santa Rosa County. It was reported to be rather severe and widespread on these 1943 late corn plantings.

It has been generally noted by workers and observers in Africa and the United States that infection and severity of attack by Puccinia polysora may be closely correlated with higher temperatures and rainfall.[3] Above normal rainfall and high temperatures during April and May in the Belle Glade area of Florida produced favorable conditions for the development of this rust in 1957. It may be present at all times as a potential disease-producing fungus.

Rust caused by Puccinia sorghi was present in a light infection at the Everglades Experiment Station in 1957. Almost all of the uredia were parasitized by Darluca filum, with the urediospores becoming displaced by pycnidia of this rust parasite. Most of the remaining urediospores were pale yellow and vacuolated. By May 21 some of the uredia of P. polysora also were parasitized by D. filum and, as the season advanced, more became parasitized.

UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, FLORIDA AGRICULTURAL EXPERIMENT STATIONS

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[3] Wood, Jessie I., and Bernard R. Lipscomb. Spread of Puccinia polysora with a bibliography on the three rusts of Zea mays. Special Publication No. 9, Plant Disease Epidemics and Identification Section, ARS, USDA, April 15, 1956.

A COMPARISON OF CAPTAN AND ARASAN FOR CORN SEED TREATMENT

Paul E. Hoppe[1]

Captan 75 (Orthocide) and Arasan 75 were compared as seed protectants for corn in cold tests in a gradient series of dosages. The dosage rates ranged from 1/4 ounce of chemical per bushel of seed to an "excess" application (2 ounces plus per bushel), with increases in 1/4 ounce increments from the lower rate to and including a 1 1/2 ounce application.

The comparisons were made on physically sound, new seed of a standard hybrid, and also on similar seed after it had been wounded at the crown by chipping off enough of the seed coat to expose the starch underneath.

The rolled towel method[2] of cold testing was used. The towels, with the kernels in contact with muck soil, were incubated 10 days at 50° F and then were moved to room temperatures (70° to 75° F), where the germinations were recorded 3 days later. All tests were in three 50-kernel replications.

RESULTS

The data from the experiment are given in Table 1.

Table 1. Percent germination in rolled towel cold tests when non-injured and crown-wounded corn kernels were treated with Arasan 75 and Captan 75 at the indicated dosages.

Fungicide[a]	Dosage (ounces per bushel)							
	0	1/4	1/2	3/4	1	1 1/4	1 1/2	Excess
	(Non-injured kernels)							
Nontreated control	13	-	-	-	-	-	-	-
Arasan 75	-	57	60	-	87	96	91	100
Captan 75	-	91	97	-	97	99	99	100
	(Crown-wounded kernels)							
Nontreated control	0	-	-	-	-	-	-	-
Arasan 75	-	1	7	23	42	50	58	92
Captan 75	-	12	71	83	93	98	98	99

[a] Tests in three 50-kernel replicates.

Both fungicides afforded good protection to the physically sound seed at dosages of 1 1/4 ounces per bushel or higher. Captan 75 retained its full potency on this type of seed at the 1/2 ounce level of application, while seed treated with Arasan 75 at that dosage germinated only 60 percent.

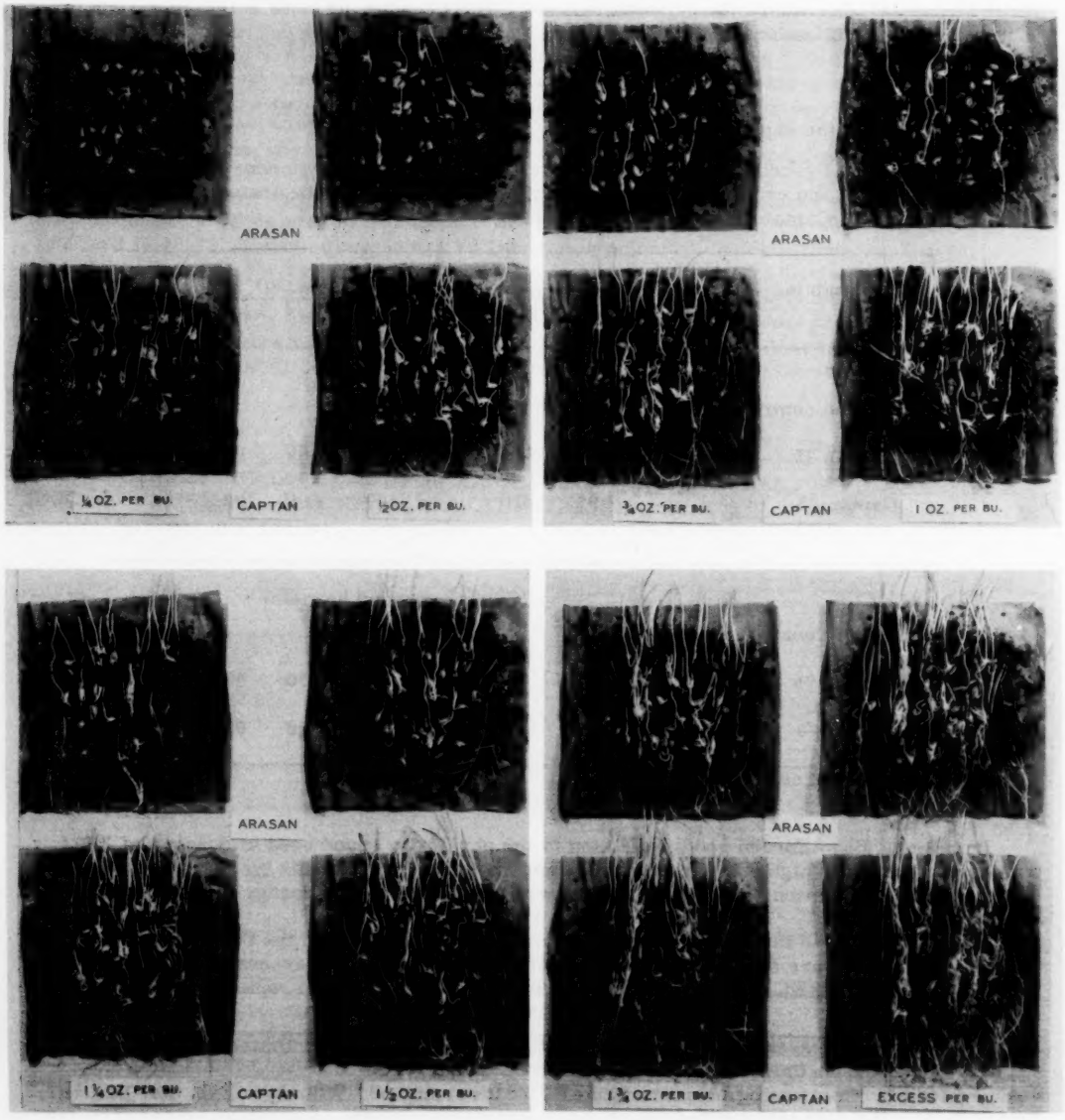
The differences in favor of Captan were even more pronounced in the tests with crown-wounded kernels. Here both products were nearly equal only at the "excess" dosage. As dosages were decreased, germination of Arasan-treated seed dropped rapidly. This was in

[1] Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the University of Wisconsin, cooperating.

[2] Hoppe, Paul E. Cold testing seed corn by the rolled towel method. Wis. Agr. Exp. Sta. Bul. 507, 1955. 5 pp.

CHECK

FIGURE 1. Germination in rolled towel cold tests when Arasan 75 and Captan 75 were compared for control of seed rot at the dosages indicated.



contrast with Captan-treated seed where good protection still was maintained at the 1 ounce level of application. At that dosage seed treated with Captan germinated 93 percent as compared with 42 percent for Arasan treatment. At the 1/2 ounce level the germination for Arasan-treated seed dropped to 7 percent, while that for Captan was 71 percent. It was only at the 1/4 ounce level of application that Captan became very ineffective. At this dosage germination for Captan-treated seed was 12 percent and for Arasan 1 percent.

Results from an experiment that was repeated with crown-wounded seed are pictured in Figure 1 (data not included here). The germinations were essentially similar to those of the earlier test, demonstrating again the superiority of Captan 75 over Arasan 75 for seedcorn, particularly when applied at lighter dosages.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND THE UNIVERSITY OF WISCONSIN

FIRST REPORT OF THE BAKANAE DISEASE OF RICE FOR U.S.A. AND PRELIMINARY STUDIES ON GROWTH STIMULATION BY CULTURAL FILTRATES

John G. Atkins[1]

Summary

Diseased rice seedlings scattered through rice fields had symptoms identical with those reported for the bakanae disease of Japan. Fusarium sp. was isolated. Symptoms similar to those observed in the field were produced in controlled tests. Cultures of the fungus added to soil containing sprouted seeds produced up to 77 percent increase in the height of rice seedlings. The response presumably was due to gibberellic acid or a similar chemical. A satisfactory method using rice seedlings for the demonstration of growth-stimulating materials was developed.

Diseased rice seedlings observed at the Rice Pasture Experiment Station, Beaumont, Texas showed symptoms that were similar to those described for the bakanae disease in Japan. Investigations of this disease are reported here.

SYMPTOMS

The symptoms exhibited by diseased rice seedlings consisted of an abnormal leaf elongation, with the plants or longest leaves bending over, yellowish or moderately chlorotic, and some browning or necrosis of the roots. Diseased plants in the field were easily detected by their abnormal height, about twice that of normal plants, and by their etiolated, slender appearance. Affected plants were scattered throughout the field rather than in groups. The incidence of the disease was only a trace. The diseased seedlings showed a browning and some decay of the roots and basal stem tissues. The necrosis was most pronounced in the subcrown internode. Diseased seedlings probably die eventually.

Normal and diseased seedlings were compared in the laboratory. Measurements of a few plants are summarized in Table 1. The conspicuous difference between normal and diseased plants was in the length of the second foliage leaf.

Table 1. Comparison of Normal and Bakanae Seedlings.

Length	Normal (inches)	Bakanae
First leaf	2.0	2.4
Second leaf	3.2	6.2
Seed to tip of first leaf	3.8	6.1
Seed to tip of second leaf	5.0	10.0
Seed to crown of plant	0.7	1.0

ISOLATIONS

Fusarium was rather consistently isolated from necrotic basal tissues. These isolates were retained for pathogenicity tests, and are designated as the B series. Isolates of the C series were from the Lacrosse rice variety (C.I. No. 8985 and F.A.O. Genetic Stock No. 1017) showing a head and boot blight at the Rice Experiment Station, Crowley, Louisiana.

The Fusarium isolates were grown on plates of potato dextrose agar and studied for identi-

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fication. Certain of the isolates appeared to be Fusarium moniliforme.

LITERATURE REVIEW

The bakanae disease was reviewed by Padwick (3) but the publications on this disease in Japanese have not been available to the writer. The disease is caused by Gibberella fujikuroi (Saw.) Wr. (Fusarium moniliforme). According to Padwick (3) cultural filtrates were found by Kurosawa and later by Seto to induce a stimulation of growth of rice seedlings and the bakanae disease symptoms. Later, Yabuta and Hayasi isolated two substances from filtrates of G. fujikuroi. One of these, called fusaric acid, retarded the growth of rice seedlings. The other material, named "gibberellin", stimulated growth. Seto apparently obtained a stimulation in some cases and a stunting or retardation in others.

Gibberellic acid and other gibberellins have recently received considerable attention in the United States and other countries because of their effects on plant growth.

EXPERIMENTAL METHODS AND RESULTS

The various isolates were grown in Erlenmeyer flasks (500 and 1000 ml) containing a nutrient solution. For the first series of tests a liquid medium was used with the following composition: sodium nitrate, 3.0 g; dibasic potassium phosphate, 1.0 g; magnesium sulfate, 0.5 g; potassium chloride, 0.5 g; sucrose 8.0 g and distilled water, 1000 ml. In later tests the Raulin-Thom medium modified by reducing the dextrose to 3 percent was used.

The rice variety Bluebonnet 50 (C.I. No. 8990 and F.A.O. Genetic Stock No. 1012) was used in all of the tests. The seed was treated with hot water (58° to 60° C for 15 minutes) to eliminate seedborne fungi.

In two tests, 5 ml of the cultural filtrate was added to Petri dishes (100 mm) containing filter paper on which 8 or 10 seeds were placed. Dry seeds were used in one test while seed sprouted 3 days at 30° C in a germinator were used in the other test. The dishes were kept in a seed germinator and observed daily until final notes were taken. Measurements of the length of the seedlings from the seed to the tip of the coleoptile or first leaf showed that none of the cultures stimulated seedling growth in this Petri dish test. Treatment of the dry seed even retarded seedling growth 50 percent or more.

In other tests the filtrates were added to 250 ml beakers approximately 1/4 full of a sand-soil mixture (2/3 sand and 1/3 screened soil, volume basis). In most of the tests 20 ml of the filtrate was added to each beaker.

Seed sprouted 3 to 5 days in a germinator were used in all except one test with dry seed. The sprouted grains were planted with the tip of the coleoptiles extending above the surface of the sand-soil mixture. Either two or three beakers were used, usually with 6 grains per beaker for each treatment. The beakers were usually held in a seed germinator for 2 to 4 days after planting, under high humidity and a relatively high temperature. The seedlings were then placed in a room where they received natural light and were watered when necessary.

The results of one test are given in Table 2. In this test unfiltered cultures withdrawn from the flasks with a pipette were added to the sand-soil mixture. Consequently, the added cultures contained some mycelia. Some sand-soil mixture was added to the beakers after planting the sprouted seed and adding the culture. As shown in Table 2, all isolates produced a marked increase in plant height and in the length of the second leaf. Many of the seedlings exhibited typical symptoms of the bakanae disease.

Ten other similar tests were conducted but the results are not presented here. Symptoms typical of the bakanae disease were present in six tests. Sprouted seed gave better and more uniform results than dry seed.

Mold growth occurred in the controls using sterile nutrient solutions and sterilized sand-soil mixtures and caused dead or abnormal seedlings.

DISCUSSION

It is believed that the disease observed in the field and the symptoms obtained in controlled experiments are the same or similar to the bakanae disease of Japan as described by Padwick (3) but this cannot be determined with certainty without consulting the Japanese literature.

Since the cultures stimulated growth, it is assumed that they contained gibberellic acid or similar substances. However, the filtrates sometimes were inhibitory.

So far as the writer can determine, the bakanae disease has not been reported in the United

Table 2. Plant measurements resulting from the addition of Gibberella cultures.

Isolate	Height (mm)			Length, second leaf (mm)		
	Average[a]	Percent increase	Range	Average[a]	Percent increase	Range
Control	96.9	--	77-121	26.9	--	9-39
B-2	138.7	43.1	97-191	84.0	212.3	33-116
B-3	171.5	77.0	114-209	114.6	326.0	98-132
B-4	133.5	37.8	82-181	81.4	202.6	30-137
B-9	126.4	30.4	80-178	67.1	149.4	29-111
C-4	132.4	36.6	82-172	74.7	177.7	56-115

[a] Averages for two replications, four to five seedlings per replicate.

States, but Fusarium species have been isolated from discolored grains by Tullis (5), Cralley and Tullis (1), the writer, and others who were investigating seedling blight. Cralley and Tullis (1) stated, "The two most common species of Fusaria isolated from diseased rice seedlings, according to Dr. C. D. Sherbakoff, resemble very closely Gibberella moniliformis (Sheldon) Wineland and Gibberella fujikuori (Saw.) Wr." Ryker and Douglas (4) and Douglas and Ryker (2) report the use of Fusarium moniliforme (presumably isolated from rice) in studies on grain discoloration (pecky rice).

It seems probable that F. moniliforme strains capable of inducing bakanae disease symptoms have been present for many years but that environmental conditions favorable for development of the disease seldom exist or else the disease was overlooked due to a low incidence. It appears to be a minor disease in the southern rice area.

Literature Cited

1. CRALLEY, E. M., and E. C. TULLIS. 1937. Effect of seed treatments on seedling emergence, severity of seedling blight, and yield of rice. Ark. Agr. Exp. Sta. Bul. 345: 1-24.
2. DOUGLAS, W. A., and T. C. RYKER. (1941?). Pecky rice investigations. Biennial Rept. of the Rice Experiment Station, Crowley, Louisiana, 1939-1940: 25-26.
3. PADWICK, G. WATTS. 1950. Manual of rice diseases. The Commonwealth Mycological Institute, Kew, Surrey. 198 pp.
4. RYKER, T. C., and W. A. DOUGLAS. (1939?). Pecky rice investigations. Biennial Rept. of the Rice Experiment Station, Crowley, Louisiana, 1937-1938: 19-20.
5. TULLIS, E. C. 1936. Fungi isolated from discolored rice kernels. U. S. Dept. Agr. Tech. Bul. 540: 1-12.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, COOPERATING WITH THE ARKANSAS, LOUISIANA, AND TEXAS AGRICULTURAL EXPERIMENT STATIONS

SMALL GRAIN DISEASES OF SOUTH CAROLINA, 1956-57 [1]

R. W. Earhart [2]

CROP RECORD

Small grain production in the southeastern United States has been increasing steadily for the past decade. In South Carolina for the cropping year 1957 the acreage of small grain was 19 percent higher in acres planted and 8 percent higher in acres harvested than the average for the decade of 1945-54. The comparison of planted and harvested areas for the State are summarized in Table 1.

There has been a constant effort towards improving crop performance by using more productive varieties and better cultural practices. While the attempts to compare performance in different years are confounded by different environmental conditions in the different cropping seasons, there has been a constant trend towards increased per acre production, which is a crude measure of the advances being made in crop performance. Per acre yields for South Carolina small grain crops are summarized in Table 2. The average yield for all small grain crops in 1957 was 10 percent higher than during the decade 1945-54; however, this was a substantial reduction from the peak year of 1956 when small grain production in South Carolina for all small grain crops averaged 25.6 bushels per acre; or 30 percent higher than for the 1945-54 period.

WEATHER

The small grain growing season from October 1956 to June 1957 could be considered as generally unfavorable for the production of these crops. At planting time the soil was extremely dry in most areas of the State, and warm dry weather persisted until the first of December, or during the entire time that the plants were becoming established. The warm fall permitted the establishment of high numbers of insects, that is, aphids and Hessian fly, which attack these crops. These same weather conditions 1) increased the activity of soil-borne pathogenic fungi, and 2) permitted the establishment of many fungal pathogens which normally are not found in South Carolina until spring, such as oat crown rust, wheat leaf rust, and the powdery mildews of wheat and barley. Following this warm dry fall was a relatively wet winter and an extremely wet spring which further aided the development of fungal pathogens. Persistence of wet weather through the normal harvesting season made grain harvesting difficult in most areas of the State.

DISEASE SURVEYS

The generally unfavorable growing season probably contributed materially to the reduced per acre yields recorded for the small grain crop in 1957. These same unfavorable growing conditions increased the severity of the diseases which attacked these crops. The various diseases and their relative importance were determined through periodic surveys of the crops during the growing period.

The South Carolina small grain disease program includes surveys of selected areas of the State at three times during the growing season to determine the presence and prevalence of the diseases during the season. The purpose of these surveys is to provide guidance for the research activity of the program.

The first or "late fall" survey is scheduled for the first and second weeks of December of each year to determine the disease situation after all plantings have emerged, but prior to the period of normal winter dormancy. At the time of this survey, the seed-borne diseases can be most accurately assessed. The second or "early spring" survey is scheduled for the first and second weeks in March to record the disease situation at the time the crops are starting early spring growth. It is at the time of this survey that diseases such as soil-borne mosaics are most apparent. The third or "pre-harvest" survey is scheduled for the first and second weeks in May, when the crop is fully headed, just prior to the normal ripening of the crop. At this final survey of the season an attempt is made to assess the amount of damage caused to the

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Table 1. Summary of planted and harvested small grain acreages in South Carolina from 1945-57.

	Wheat	Oats	Barley	Rye	Total	Percent
	Acres: Average from 1945-54					
Planted	180,000	790,000	23,000	29,000	1,022,000	100.0
Harvested	175,000	523,000	20,000	10,000	728,000	71.2
Difference*	5,000	267,000	3,000	19,000	294,000	28.8
	Acres: 1955					
Planted	166,000	990,000	34,000	45,000	1,235,000	100.0
Harvested	152,000	551,000	22,000	15,000	740,000	60.0
Difference*	14,000	439,000	12,000	30,000	495,000	40.0
	Acres: 1956					
Planted	187,000	911,000	44,000	48,000	1,190,000	100.0
Harvested	179,000	551,000	33,000	16,000	779,000	66.0
Difference*	8,000	360,000	11,000	32,000	411,000	34.0
	Acres: 1957					
Planted	194,000	911,000	65,000	47,000	1,217,000	100.0
Harvested	186,000	540,000	46,000	16,000	788,000	65.0
Difference*	8,000	371,000	19,000	31,000	429,000	35.0

* Planted acres not harvested for all reasons: forage utilization, green manuring and abandoned.

Table 2. Per acre yields of small grain crops in South Carolina.

Crop	1945-54 Bushels	1955 Bushels	1956 Bushels	1957 Bushels
Wheat	16.4	19.5	22.5	18.5
Oats	27.6	27.5	36.0	30.5
Barley	24.1	20.5	30.0	25.0
Rye	10.6	11.0	14.0	13.0
Average	19.7	19.3	25.6	21.7

crop by diseases.

METHOD OF SURVEY

Each survey consists of an intensive coverage of 12 major small grain producing counties of the State. These counties are so located as to provide a sample of each of the three major geographic or cropping areas of South Carolina. The counties surveyed are:

Piedmont -- Oconee, Anderson, Newberry, Saluda, York, and Chester.
Coastal Plain area -- Orangeburg, Hampton, Lee, and Sumter.
Tobacco area -- Marlboro and Dillon.

In each county stops are made at 4-mile intervals along a pre-established route which includes all parts of the county. From one to four fields are visited at each stop. No effort is made before stopping to determine the crop visited; in this manner, it is hoped that the numbers of fields in each crop surveyed will be based upon the density of that crop within the county. By this method, the percentages of the different crops in the fields visited will vary from one county to another, but the state-wide survey percentages have closely approximated the percentages of the acreage of the crops being grown as reported by the Crop Reporting Service. Table 3 represents a summary of small grain fields visited in South Carolina during the 1956-57 season.

Rye is omitted from Table 3 since only 15 rye fields were included in the annual survey: 10 in the Coastal Plain, 3 in the tobacco area, and 2 in the Piedmont.

At each of the fields visited a record is made of the location, crop, and diseases noted, and the relative severity of each disease. Severity is determined for each disease on the basis of visible damage, but specimens are collected for laboratory confirmation of field diagnosis. These severity categories are: "clean", where no visible infections are noted; "low", where diseases are noted, but not thought to be causing damage; "medium", where disease is present and doing some damage; and "high", where disease is present and thought to be doing considerable damage.

The data collected are compiled and issued in a mimeographed report summarizing the disease situation of these crops at the times of each survey trip. Annual summaries are prepared from the three survey reports and issued separately. The results from the surveys from December 1956 to May 1957 are included herein.

RESULTS OF THE 1956-57 SMALL GRAIN DISEASE SURVEY

For the simplest presentation of the results of the surveys, the diseases of each crop are presented and discussed as a unit. In this manner, the annual progression of disease damage can be followed on one crop at a time.

Oat Diseases

South Carolina farmers planted oats on 1,217,000 acres during October and November of 1956 and this spring harvested 540,000 acres for grain. These acres yielded 16,470,000 bushels of oats, or 30.5 bushels per acre. The diseases found attacking this crop, based on our periodic surveys, are summarized below.

Oat leaf spot, caused by Helminthosporium avenae, was found infecting more acres of oats in South Carolina than all other diseases. The amount of damage from this disease was considered medium to severe for the season. Data[3] available from tests conducted in fields with high amounts of leaf spot infections indicate that yield reductions as high as 66 percent may occur under these severe infections.

Table 4 summarizes the distribution of severity of leaf spot, by area and time, for the 1956-57 cropping season.

Culm damage, caused by the seed and soil-borne pathogens, Helminthosporium sativum and H. victoriae, is best evaluated when the plants are in the seedling stage of maturity. At

[3] Unpublished data from manuscript in preparation.

Table 3. Numbers of fields, by crops and areas, visited during the 1956-57 small grain disease surveys.

Crop	Time of survey	Areas of state			State totals
		Piedmont	Coastal Plain	Tobacco area	
Oats	December	86	45	29	160
	March	119	62	44	225
	May	104	58	33	195
	Total	309	165	106	580
Wheat	December	24	25	9	58
	March	54	31	9	94
	May	70	41	12	123
	Total	148	97	30	275
Barley	December	11	5	5	21
	March	11	6	5	22
	May	15	11	7	33
	Total	37	22	17	76
Survey total		494	284	153	931

Table 4. Distribution and numbers of fields with varying degrees of damage due to oat leaf spot (Helminthosporium avenae) in South Carolina 1956-57.

Area	Time	Severity				Totals
		Clean	Low	Medium	High	
Piedmont	December	24	25	24	3	76
	March	7	49	52	11	119
	May	5	43	45	11	104
	Totals	36	117	121	25	299
Coastal Plain	December	21	14	10	0	45
	March	8	39	11	4	62
	May	7	20	24	7	58
	Totals	36	73	45	11	165
Tobacco area	December	14	5	8	2	29
	March	3	19	14	8	44
	May	0	3	19	11	33
	Totals	17	27	41	21	106
Survey totals		89	217	207	57	570

this time (December survey) the seed-borne infections can usually be differentiated from the soil-borne infections. These diseases cause damage all during the growing season, but their effects tend to be masked by other diseases later in the season. The distribution of these culm damaging diseases on the oat crop in South Carolina in December of 1956 is summarized in Table 5.

Oat crown rust, caused by Puccinia coronata avenae, was present in the oat crop of South Carolina in December, but very little spread was noted from early established infection centers until the last half of April. Some of the fall-established infection centers disappeared during the winter and only a little carry-over occurred in South Carolina this year. The majority of the infections noted at the beginning of May resulted from wind-borne spores from Florida and southern Georgia. There was a steady progression of crown rust infection across South Carolina from southwest to northeast as the season progressed. The state-wide infection was assessed in early May and these results are summarized in Table 6. Infections were present in the Coastal Plain about 2 to 3 weeks before they became widespread in the Piedmont, but actual damage in the Coastal Plain was less than in the Piedmont. This occurred since the oat crop in the Coastal Plain matured early and quickly during a warm dry period at the last of April, while in the Piedmont ripening was prolonged by a cooler moist period early in May.

In addition to the three diseases listed above, which have been reported separately because of their uniform prevalence in South Carolina, nine other diseases or disease conditions were recorded in the surveys of the oat fields during the 1956-57 growing season. These are summarized in Table 7.

Wheat Diseases

Wheat was planted on 194,000 acres in South Carolina during the fall of 1956. Of these 194,000 acres only 186,000 were harvested for grain. Based on the June 15 market price, this harvested wheat crop was worth $6,469,000 to the farmers of the State. The diseases that were located during the small grain disease surveys on wheat are summarized below.

Wheat leaf rust, caused by Puccinia recondita tritici (P. rubigo-vera tritici), was the most damaging disease during the past season, followed closely by powdery mildew. While leaf rust was state-wide in its occurrence, the heaviest infections were recorded in the Piedmont due to the lateness of the crop in that area. Table 8 summarizes the distribution of leaf rust infections found in May of 1957.

Wheat powdery mildew, caused by Erysiphe graminis tritici, was the most prevalent of the diseases attacking wheat at the time of the March survey, but it was considered second to leaf rust in the amount of damage caused to the crop during the entire year. In some parts of the State, primarily the Coastal Plain and tobacco areas, powdery mildew probably caused as much yield reduction as leaf rust, but the seriousness of the latter in the Piedmont late in the season influenced the decision to consider leaf rust as the most damaging disease. The distribution of powdery mildew damage in March and May is summarized in Table 9.

Wheat Septoria diseases, caused by Septoria nodorum and S. tritici, have been increasing in importance as pathogens of the crop in South Carolina during the past three seasons. During the past season Septoria damage was state-wide in occurrence and was exceptionally severe in the Piedmont. On one farm in Anderson County where adequate records were maintained, it was estimated that a 50 percent reduction of yield that could be mainly attributed to Septoria damage occurred in Anderson wheat. The state-wide distribution of Septoria damage to wheat, as reported in the March and May surveys, is summarized in Table 10.

In addition to the wheat diseases tabulated above, loose smut, caused by Ustilago tritici, and stem rust, caused by Puccinia graminis tritici, were found attacking the wheat crop in South Carolina. Loose smut was located in 12 fields in the Piedmont and 6 in the Coastal Plain. The amount of infection in these fields was not considered as damaging, but the presence of these diseases does pose as a potential threat to the wheat crop. Stem rust was located in only two fields in the State, both in the Piedmont, including 1 each in Newberry and Chester Counties. In both of these fields the centers of infection were limited in size, but the plants within these centers were showing complete susceptibility.

Table 5. Distribution of oat fields with varying amounts of culm damage (*Helminthosporium* spp.) in South Carolina, December 1956.

Area	Severity				Totals
	Clean	Low	Medium	High	
Piedmont	32	19	27	8	86
Coastal Plain	3	10	29	3	45
Tobacco area	0	1	19	9	29
Totals	35	30	75	20	160

Table 6. Distribution of oat fields in South Carolina in May * of 1957 showing varying damage from oat crown rust.

Area	Severity				Totals
	Clean	Low	Medium	High	
Piedmont	9	61	23	11	104
Coastal Plain	25	24	8	1	58
Tobacco area	14	16	1	2	33
Totals	48	101	32	14	195

* One field each in the Coastal Plain and Piedmont showed crown rust in December of 1956, 2 fields in the Piedmont and 1 in the tobacco area had infections in March of 1957.

Table 7. "Other" diseases recorded on oats in South Carolina, 1956-57.

Diseases	Number of fields			Total
	Piedmont	Coastal Plain	Tobacco area	
Red leaf[a] *	38	33	24	95
Soil-borne mosaic ***	55	4	13	72
Culm rot ***	22	18	15	55
Oat smuts[b] **	23	19	12	54
Yellowing[c] *	9	3	3	15
Black stem **	6	0	0	6
Halo blight ***	2	1	2	5
Powdery mildew ***	1	2	1	4
Stem rust **	3	0	0	3

a Some plants showing this "type" of symptoms were determined to be infected by cereal yellow dwarf virus.
b Includes both loose and covered smuts of oats.
c Yellowing symptoms due to unknown causes; in the Coastal Plain and tobacco areas some of this trouble was due to high soil pH.
* Found in March only.
** Found in May only.
*** Found in both March and May.

Table 8. Distribution by percent of wheat fields in South Carolina in May 1957 showing varying damage from leaf rust.

Area	Clean Percent	Low Percent	Medium Percent	High Percent	Number of fields
Piedmont	0	16	60	24	70
Coastal Plain	5	29	39	27	41
Tobacco area	17	25	33	25	12
Total	7	23	45	25	123

Table 9. Distribution of wheat fields, by percent, in South Carolina showing varying amounts of damage from powdery mildew in March and May 1957.

Area	Time	Percent with degree of severity: Clean Percent	Low Percent	Medium Percent	High Percent	Number of fields
Piedmont	March	4	31	59	6	54
-	May	34	17	32	17	70
Coastal Plain	March	0	14	60	26	31
	May	29	32	27	12	41
Tobacco area	March	0	55	34	12	9
	May	33	17	33	17	12
Average	March	2	33	51	14	94
	May	32	22	31	15	123
(Both months)		18	28	41	13	217

Table 10. Distribution, by percent, of the wheat fields in South Carolina showing damage by Septoria diseases in March and May 1957.

Area	No. of fields	Severity May: Clean Percent	Low Percent	Medium Percent	High Percent	:	Percent infected March
Piedmont	70	0	50	31	19	:	63
Coastal Plain	41	29	41	20	10	:	10
Tobacco area	12	25	33	17	25	:	11
Average	123	12	46	26	16		28

Barley Diseases

Barley was planted on 65,000 acres in South Carolina last fall and the farmers of the State harvested 46,000 acres. They obtained 1,150,000 bushels of grain, or a yield of 25 bushels per acre. Barley production in the State is slowly increasing as more disease resistance is incorporated into varieties available to growers. However, disease losses are still high, with spot blotch caused by Helminthosporium sativum, loose smut caused by Ustilago nuda, and scald caused by Rhynchosporium secalis, being the most widespread diseases. Leaf rust caused by Puccinia hordei is of secondary importance in limiting production because of the resistance available in the variety Davie; however, susceptible varieties are seriously damaged each season.

Among the "lesser" important diseases of barley in South Carolina were: stripe caused by Helminthosporium gramineum, and scab caused by Gibberella saubinetti [G. zeae]. However, recent work[4] indicates that seedling damage to barley and other small grains due to the "Fusarium" stage of the scab organism may be a serious factor in obtaining stands, especially early seeded grain. Table 11 summarizes the distribution of barley fields infected with the "major" diseases at the time of the different disease surveys during the 1956-57 cropping season.

Table 11. Distribution of barley fields infected with "major" diseases as located during the 1956-57 small grain disease surveys.

Time		Distribution of infected fields			No. fields[a]	
		Piedmont	Coastal Plain	Tobacco area	Inf.	Sur.
December	Spot blotch	2	2	4	8	21
March	Powdery mildew	7	6	4	17	22
	Spot blotch	6	2	5	13	22
	Scald	4	1	1	6	22
May	Spot blotch	11	11	5	27	33
	Powdery mildew	9	10	5	24	33
	Scald	7	4	1	12	33
	Leaf rust	7	2	1	10	33

[a] Number of fields "Inf" - infected; "Sur" - surveyed.

Rye Diseases

Rye was planted on 47,000 acres last fall, but only 16,000 acres were harvested this summer. Rye in South Carolina is primarily a forage crop and generally only enough seed is harvested to supply planting needs for the next season. Only three diseases were noted in the few fields surveyed: these were leaf scorch caused by Helminthosporium tritici-repentis, leaf rust caused by Puccinia recondita secale (P. rubigo-vera secale), and powdery mildew caused by Erysiphe graminis secale. On these three, leaf rust is considered to be the most important in contributing to production losses.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATIONS, CLEMSON

[4] Mc Carter, M. W., Jr. 1957. "Early season seedling damage to small grains associated with Fusarium species". Thesis submitted in partial fulfillment of requirements for the Master of Science Degree, Clemson Agricultural College.

THE GRAY-LEAF-SPOT DISEASE OF ST. AUGUSTINE GRASS

Isaac Malca M. and John H. Owen[1]

Summary

The gray-leaf-spot disease of St. Augustine grass, Stenotaphrum secundatum, caused by Piricularia grisea, is very destructive in Florida during the summer months, particularly during periods of heavy rainfall and high humidity. Inoculation experiments showed that the isolates of Piricularia from St. Augustine grass and crabgrass were pathogenic on both of these hosts but not on centipede grass, Bermuda grass, and Emerald zoysia grass.

Histopathological studies of P. grisea on St. Augustine grass indicated that the fungus was capable of penetrating the host through stomata and by direct penetration of the epidermis, and that after entering the host it caused collapse of the mesophyll cells, forming the depression characteristic of the gray-leaf-spot lesions.

The gray-leaf-spot disease of St. Augustine grass, Stenotaphrum secundatum, caused by Piricularia grisea, appears in scattered locations in Florida lawns soon after the first heavy spring rains. It continues to spread rapidly so that by mid-June few lawns are free of the disease. The disease is frequently severe during the summer months, especially during rainy weather or prolonged periods of high moisture.

Symptoms appeared on actively growing tissue 5 days after inoculation, and in periods of high humidity the lesions enlarged rapidly, producing a typical blue-gray cast due to the presence of conidiophores. The spores are wind disseminated, and frequent rainfalls provide high humidity for germination and host penetration.

By the beginning of the summer the disease is well established and can be found in practically every lawn of St. Augustine grass. When dry periods of 10 days or more occur along with high temperatures, the disease appears to diminish considerably in the field, but closer examination reveals that only the new growth is free of the disease. Spores harbored in the lower, previously infected leaves serve as a source of inoculum, and when favorable conditions for disease development recur, the new growth becomes infected.

There appeared to be a definite correlation between actively growing tissue and the percentage of infection. St. Augustine grass developing poorly in unfertilized plots failed to show infection even though heavy infection occurred on the same plots the previous year. In inoculation experiments very slight infection was obtained unless the grass was growing actively, and the inoculated plants were subjected to 4 hours continuous wetting following inoculation.

SYMPTOMS

Lesions commonly occur on the leaf blades where they appear first as minute brown dots which enlarge rapidly under moist conditions to form oval and later elongate areas. Sporulating lesions are characterized by depressed, blue-gray centers, and slightly irregular brown margins with some marginal chlorosis (Fig. 1). Mature spots are elongate along the longitudinal axis of the leaf, and the centers of the older and non-sporulating lesions become tan and are dried and wrinkled. Lesions generally range from 0.2 to 0.7 cm but may be as long as 2 cm in length, especially when they occur on the margins of the leaf blades. They are usually concentrated along the midrib but may also occur at the base, tip and margins of the blade. During favorable conditions for disease development as many as 30 or more lesions develop on a single leaf blade, causing chlorosis and death of the leaf.

Symptoms on the sheath closely resemble those on the blades. In addition, brown to black, usually elongate, spots appear on the culms. Lesions also occur on the spikes, but these usually have irregular margins and tan centers. Culm and spike lesions are not very common

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[1]Former graduate student, Department of Plant Pathology, University of Florida, now graduate student, Department of Botany and Plant Pathology, Purdue University; and Associate Professor of Plant Pathology, University of Florida, respectively.

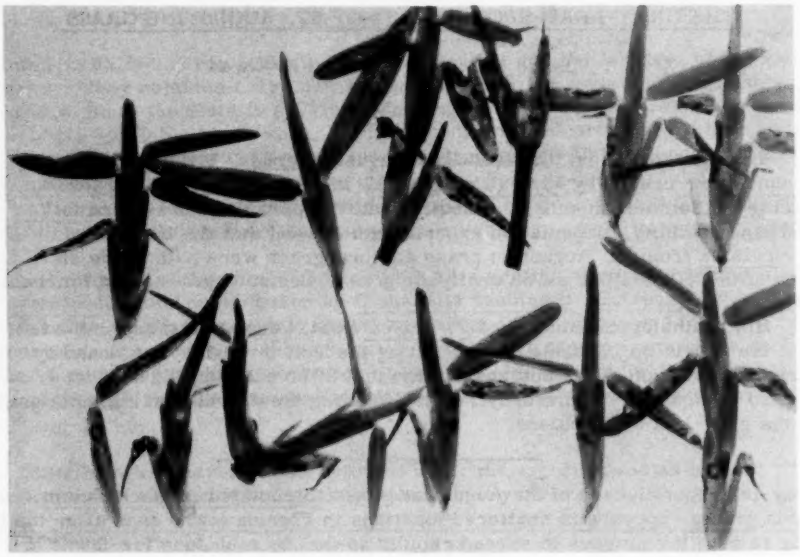


FIGURE 1. Sporulating lesions on leaf blades and sheaths of St. Augustine grass naturally infected by P. grisea.

except during periods of severe infection.

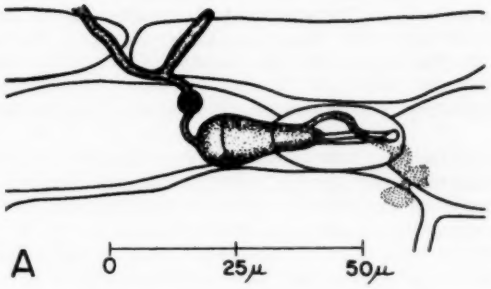
PATHOGENICITY

Healthy sprigs of St. Augustine grass, Stenotaphrum secundatum, Bermuda grass, Cynodon dactylon, crabgrass, Digitaria sanguinalis, centipede grass, Eremochloa ophiuroides, and Emerald zoysia grass, a hybrid between Zoysia japonica and Z. tenuifolia, were planted in 6-inch clay pots and grown under greenhouse conditions.

Several isolates of Piricularia grisea from St. Augustine grass were grown on artificial culture media. These isolates sporulated abundantly on a 2 percent rice polish agar and on V-8 juice agar. Inoculation experiments were conducted by atomizing the leaf blades of the grasses tested with spore suspensions of the isolates from St. Augustine grass. Two replicates of each grass were used in each experiment. In some of the inoculation experiments Tween 80 was used as a wetting agent; however, in an attempt to increase the percentage of infection, a spreader-sticker solution of sodium oleate and gelatin was used (1). The inoculated plants were then subjected to periods of 10 to 48 hours of continuous wetting in a moist chamber. Prior to inoculation the leaf blades were rubbed gently to remove some of the cutin. Plants inoculated with the fungus from crabgrass were subjected to the same treatment as those inoculated with the isolates from St. Augustine grass; however, the inoculum from crabgrass was obtained directly from sporulating lesions of naturally infected crabgrass leaf blade

Fourteen inoculation experiments were made with isolates of P. grisea from St. Augustine grass onto St. Augustine grass, and four experiments were conducted using spores of the crabgrass fungus on St. Augustine grass. Centipede grass, Bermuda grass and Emerald zoysia grass were used in eight experiments where inoculations were made using the St. Augustine grass isolates and in three experiments using spores taken from lesions on crabgrass. Crabgrass was used in three experiments and was inoculated with spores from the St. Augustine grass and from crabgrass.

No infection of centipede grass, Bermuda grass, or Emerald zoysia grass was obtained with either the isolates from St. Augustine grass or with spores from crabgrass. The isolates



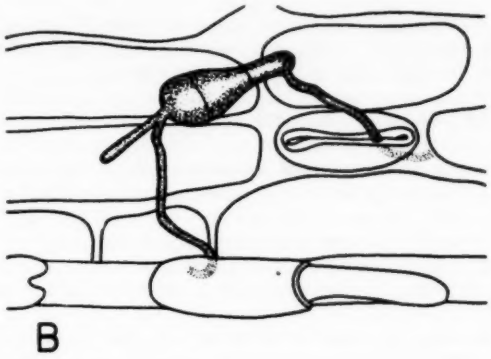
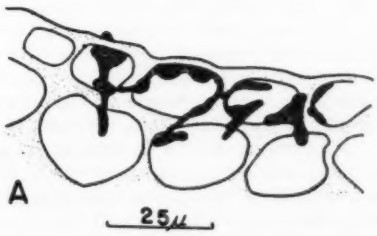


FIGURE 2. Camera lucida drawings of (A) stomatal penetration, and (B) both stomatal and direct penetration through the base of a trichome of a St. Augustine grass leaf blade by spores of P. grisea.



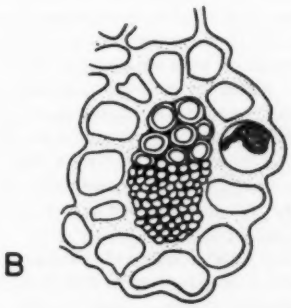


FIGURE 3. Camera lucida drawings of sections of St. Augustine grass leaf blades infected with P. grisea showing: (A) spore penetration forming a haustorium and growth of the fungus in the host, and (B) the presence of the fungus in the bundle sheath.

from St. Augustine grass were capable of infecting crabgrass, although only slight infection was obtained. The isolates from crabgrass were found to infect only St. Augustine grass in addition to its own host. It caused severe infection on St. Augustine grass in two of the four inoculation experiments. Inoculation of St. Augustine grass with isolates of P. grisea from St. Augustine grass resulted in varying degrees of infection. In 14 inoculation experiments moderate infection was obtained six times, heavy infection two times, and no infection in the remaining six tests.

Although the disease spread rapidly in the field, it appeared that environmental factors greatly influenced disease development. Field observations and inoculation experiments indicated that three factors which were commonly associated with disease development were actively growing susceptible tissues, high humidity, and moderate temperatures (70° to 90° F).

Lesions appeared 5 to 6 days after inoculation as minute brown dots which enlarged to form the characteristic sporulating lesion within 24 hours when exposed to high humidity. Heaviest infection was obtained when plants were allowed to remain in the moist chamber for 24 hours or more after inoculation.

These experiments have shown that cross-inoculation can be obtained with P. grisea on St. Augustine grass and crabgrass, and that crabgrass, a common weed grass, infected with P. grisea can serve as a source of inoculum for infection of St. Augustine grass.

SPORE PENETRATION STUDIES

Detached leaves of St. Augustine grass were atomized with a heavy spore suspension of Piricularia grisea from St. Augustine grass, placed in a moist chamber, and incubated at 22° to 24° C. The leaf blades were then cut into 5 mm squares and samples were collected after 16 and 24 hours and placed in 1:1 lactic acid and 95 percent ethyl alcohol for 48 hours. The sections were cleared in 70 percent lactic acid for 4 days and stained with 0.1 percent cotton blue in lactophenol for 15 to 30 minutes as recommended by Diener (2). Restaining of the sections prior to use gave better results.

The fungus was capable of penetrating the host through the stomata and also by direct penetration through the epidermis. Germ tubes that entered through stomata showed a slight thickening at the point of entry which stained considerably darker than the rest of the tube. No distinct appressoria were formed in those cases where stomatal penetration had occurred (Fig. 2, A). The germ tube entered the leaf and then grew into adjacent cells.

For every case of stomatal penetration evidenced, at least one instance existed in which the germ tube passed over the stoma and did not enter. In most instances the germ tube continued its growth superficially over the host tissue regardless of the proximity of the stomata. In one case a germ tube was observed growing into a stomatal opening but apparently was not able to gain entrance into the host; it reemerged and continued its superficial growth.

Approximately 15 percent of the germ tubes that penetrated the host tissue entered through stomata, while the vast majority penetrated directly after forming an appressorium. Not all of the germ tubes that produced appressoria were capable of penetrating the epidermis; nor did appressoria limit the superficial growth of the fungus, for hyphae sometimes emerged from the lateral side of the appressorium and continued its superficial growth.

Appressoria varied considerably in size, ranging from 4 to 12 μ in diameter. They were invariably flat to slightly elevated and stained deeply with cotton blue. The first sign of appressorium formation was an enlargement of the tip of the germ tube, producing a bulbous-like structure. When fully developed the appressorium appeared as a separate thick-walled cell, and a slender penetration tube emerged from the base of the appressorium, penetrated the epidermis, and invaded the epidermal cells.

Germ tubes were sometimes observed to enter the host directly without the formation of an appressorium. In one case, direct penetration through the base of a trichome was observed (Fig. 2, B). After entering the trichome the hypha curled and grew in the direction of the epidermal layer.

After the fungus had gained entrance into a cell the hypha enlarged considerably, especially when it came in contact with the inner part of the cell wall, and sent out a narrow hypha into the intercellular space. This hypha was capable of entering adjacent cells, and once inside the cell it again enlarged considerably.

Sections examined 16 hours after inoculation showed that most of the germ tubes had formed appressoria by this time, but only in a few instances had the fungus penetrated the host. Within 24 hours after inoculation the germ tubes had already penetrated the host and had become established. Spore germination studies indicated that 95 percent of the germ tubes formed

appressoria in distilled water and in 0.75 percent sucrose solution in 10 1/2 hours after incubation at temperatures of 24° to 31° C.

PATHOLOGICAL ANATOMY

Leaves of St. Augustine grass infected with Piricularia grisea were collected from the field, killed, and fixed in FAA for 36 hours. They were then placed in 50 percent alcohol, after which time they were passed through a dehydration series with the butyl-alcohol series proposed by Johansen (3). Infiltration was carried out with parowax, and tissue mat was used for final embedding and blocking. Sections 10 to 15 μ thick were cut with a rotary microtome and mounted in Canadian balsam. Best results were obtained using safranin and light green stains.

Once inside the epidermal cell, the penetration hypha formed an haustorium from which hyphae were extruded which were capable of penetrating adjacent cells (Fig. 3, A). Apparently direct penetration commonly occurred through the motor or bulliform cells. Leaves of St. Augustine grass have large parenchymatous cells on both sides of the vascular bundles, and smaller mesophyll cells between the bundles. The fungus grew from the original infected epidermal cell to adjacent epidermal cells or into the large parenchymatous cells. When the smaller mesophyll cells between the vascular bundles were invaded the fungus began active growth until it reached a vascular bundle, where invasion was apparently retarded. Once inside the mesophyll cells, the mycelium caused collapse of these cells, forming the depression observed on the gray-leaf-spot lesions on St. Augustine grass. Along the border of the collapsed cells, mesophyll cells with actively growing mycelium were intact or only partially collapsed. This layer consisted of three or four cells which bordered the disintegrated or collapsed region. Beyond this zone there existed a third zone where the cells were apparently discolored, since they stained differently from healthy host tissue. There was little evidence of mycelium occurring in this region.

Vascular bundles generally showed no traces of the fungus. However, in a few cases there was evidence of mycelium in the bundle sheath (Fig. 3, B). No mycelium was observed in the phloem or xylem. Mycelium was found in the large parenchymatous cells between the vascular bundles and the epidermis, but there was no evidence of collapse of these cells.

These observations were similar to those made by Yoshii (4), in 1937, on the histopathological studies of rice infected with Piricularia oryzae.

Literature Cited

1. ANDERSON, A. L., and B. W. HENRY. 1946. The use of wetting and adhesive agents to increase the effectiveness of conidial suspensions for plant inoculations. Phytopathology 36: 1056-1057.
2. DIENER, U. L. 1955. Host penetration and pathological histology in gray leaf spot of tomato. Phytopathology 45: 654-658.
3. JOHANSEN, D. A. 1940. Plant microtechnique. McGraw-Hill, New York. 523 pp.
4. YOSHII, H. 1937. Pathological studies on rice blast, caused by Piricularia oryzae. III. Patho-histological observations of diseased plants. (Abst.) Rev. Appl. Mycol. 16: 557.

DEPARTMENT OF PLANT PATHOLOGY, UNIVERSITY OF FLORIDA, GAINESVILLE

SEVERE DAMAGE FROM BACTERIAL STEM BLIGHT OF ALFALFA IN MISSOURI [1]

Marvin D. Whitehead and Emmett L. Pinnell

A general infection of bacterial stem blight of alfalfa, Pseudomonas medicaginis, occurred in Missouri apparently following frost injury of a statewide late freeze, April 11-14, 1957. At Columbia a 19-hour period of below freezing temperatures with a low of 23°F on April 11 and 12 and a 12- and 13-hour period of freezing temperatures with a low of 25° on April 12 and 13 apparently incited considerable injury in the form of stem cracking.

Lesions commonly occurred on the stem in association with frost cracks. Seventy-five percent of the fields observed on a statewide survey just prior to time of first cutting May 20-22 had developed a moderately heavy to severe infection. Some fields were observed to have 50 percent of the early stems blighted.

As described by Richards (1) and Sackett (2, 3) the disease appears as dark brown to black blotches on the stems and foliage. Stem lesions first appear as translucent green blotches 1 mm in diameter that change to black on tissue necrosis. A limited glistening exudate forms on stem lesions. Lesions may coalesce and enlarge to cover the entire length of the stem, Fig. 1 B. Stem blighting occurs when tissue necrosis has advanced around the stem. Blighting may occur on early growth through to mature stems. Blackened stems become brittle near the base.

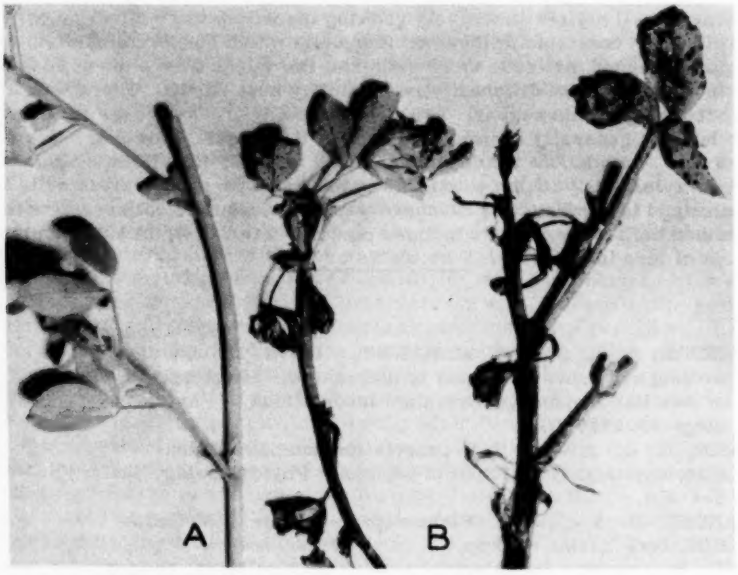


FIGURE 1. Bacterial stem blight of alfalfa. A. Healthy. B. Blighted plants showing leaf and stem lesions.

Leaf lesions appear as small black blotches 1 to 3 mm in diameter with irregular margins that may coalesce to form elongate lesions or may consume the entire leaf. Leaf blighting occurs from numerous leaf or petiole lesions, Fig. 1 B.

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There seemed to be slight differences in resistance of standard varieties grown in the alfalfa observation and yield nurseries at Columbia, Missouri with Ladak and Vernal showing the highest resistance. Quite a number of Plant Introductions of the low crown types showed good resistance.

Literature cited

1. RICHARDS, B. L. 1934. Reactions of alfalfa varieties to stem blight. Phytopathology 24: 824-827.
2. SACKETT, W. B. 1910. A bacterial disease of alfalfa. Colo. Agr. Exp. Sta. Bul. 158.
3. SACKETT, W. B. 1910. A new alfalfa disease -- stem blight. Colo. Agr. Exp. Sta. Bul. 159.

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RECENT DEVELOPMENTS ON THE CONTROL OF FOLIAR DISEASES OF TOMATO IN SOUTH FLORIDA

R. S. Cox and N. C. Hayslip[1]

Abstract

The tomato growing season in south Florida may be divided into three periods, each characterized by certain weather patterns and accompanying diseases. In field trials information was obtained on control of bacterial spot, late blight, gray leaf spot, and gray mold. Streptomycin was less effective than copper against bacterial spot; a mixture of the two was more effective than either alone. Under conditions of one of the worst late blight epiphytotics in the history of south Florida, maneb and zineb provided control which was superior to that of any other material tested. Zineb with thiram, dichlone or ferbam, each at reduced dosages, provided control equal to that of zineb. Dyrene was most effective against gray leaf spot; maneb and zineb, intermediate, and dichlone, least effective. Plots sprayed with dichlone, dichlone-Dyrene mixture, and dichlone-copper-Dyrene-streptomycin mixture contained the least amount of gray mold; but not significantly less than zineb in mixture with thiram, ferbam or copper-Agrimycin. Maneb, zineb and nabam-zinc sulfate plots contained the greatest amount of gray mold. Nabam-zinc sulfate again caused moderate injury. The copper-Agrimycin-Dyrene-dichlone mixture caused a light to moderate leaf distortion.

Successful tomato production on the sandy soils of south Florida is absolutely contingent upon the control of several foliar diseases. These include bacterial spot (Xanthomonas vesicatoria (Doidge) Dows.) late blight (Phytophthora infestans (Mont.) d By.), gray mold (Botrytis cinerea Fr.) and gray leaf spot (Stemphylium solani Weber). Each of these diseases causes severe losses to some plantings almost every year. To control a disease with maximum efficiency the grower should know when, and under what conditions to expect it to appear initially and, likewise, under what conditions he can normally expect the disease to develop into a serious problem.

The tomato growing season in south Florida starts in August, when first seedings are made, and continues into April and May of the following year. Thus, the plantings are subjected to a wide range of weather conditions. For this reason the tomato growing season may be divided conveniently into three periods:

Period 1 includes the months of August through October -- the rainy season. This period is characterized by warm, wet weather at its inception, and cool, wet weather toward its close. The most serious disease problem during this time probably is bacterial spot, although gray leaf spot frequently is important. Late blight occasionally develops during the latter part, particularly if exceptionally cool, wet weather occurs.

Period 2 extends from November 1 through March. It is characterized by intervals of low temperatures accompanied by heavy dews and fogs. Rainfall is relatively light as a rule, but excessively wet periods, such as were the months of February and March, 1957, are not uncommon. Late blight and gray mold are of paramount importance during this period. It is well known that cool, wet weather is conducive to late blight development. Optimum conditions for gray mold development are somewhat more obscure. It is generally believed, nevertheless, that cool, wet weather favors gray mold. Still, gray mold and late blight are not necessarily present in epiphytotic amounts under the same set of conditions. For example, the past season (1956-57) was one of the worst for late blight, while gray mold was present only in light to moderate amounts along the Florida east coast.

In addition to circumspection relative to late blight and gray mold, vigilance against bacterial spot and gray leaf spot cannot be relaxed during Period 2. Bacterial spot can be particularly troublesome if adequate control was not obtained during Period 1.

Period 3 comprises the last part of the growing season, beginning with April. The disease

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Table 1. Effect of various combinations of streptomycin and copper on the severity of bacterial spot. Indian River Field Laboratory. 1956.

Materials[a]	Concentration (pounds per 100 gallons, or parts per million	Disease severity[b] Test #1 seeded Sept. 7	Test #2 seeded Sept. 21
Check		8.6	7.8
Agrimycin-100	50 ppm	7.2	7.4
Agrimycin-100	100 ppm	6.4	7.6
Agrimycin-100	200 ppm	6.2	6.8
Agristrep	50 ppm	6.8	7.4
Agristrep	100 ppm	6.8	6.8
Agristrep	200 ppm	4.2	4.2
TBCS[a]	4 lbs.	4.6	5.2
Agrimycin plus TBCS	50 ppm plus 4 lbs.	3.8	5.0
Agrimycin plus TBCS	100 ppm plus 4 lbs.	3.2	4.2
Agrimycin plus TBCS	200 ppm plus 4 lbs.	2.8	3.2
Agrimycin plus TBCS	50 ppm plus 4 lbs.	3.2	4.2
Agrimycin plus TBCS	100 ppm plus 4 lbs.	2.2	3.4
Agrimycin plus TBCS	200 ppm plus 4 lbs.	4.2	5.4
L.S.D. .05		1.6	1.7
L.S.D. .05		2.1	2.2

[a] TBCS = Tribasic Copper Sulfate, 53% metallic copper; Agrimycin-100, 15% streptomycin sulfate, 1.5% oxytetracycline.
[b] Plots scored on a 0 to 11 basis where 11 equals complete defoliation.

problems during this time depend upon the current weather conditions and the carry-over of disease inoculum from the preceding periods. This period is characterized by increasing shower activity and more frequent periods of hot weather. Thus, it is readily seen that any of the four major diseases can be of primary importance during the third period.

The control program during any of these three periods depends upon the disease inoculum present and the prevailing weather. It is now possible to single out any one of the diseases mentioned here and to recommend a spray program which, if followed properly, will provide adequate control under most conditions. However, there is small comfort in controlling one disease only to have the crop destroyed by another. Since it is not yet possible to recommend a single material which will control all of the diseases, a rather complicated and flexible program for this complex problem is necessary. Work in pursuance of this goal has been underway for the past two seasons at the Indian River Field Laboratory. Considerable progress has been made.

The purpose of this report is to bring together the latest findings on control of each disease.

EXPERIMENTAL TRIALS

Fall Test (Bacterial Spot)

Materials and Methods: This test was run on duplicate, adjacent plantings of the Manalucie variety during the fall of 1956. The first planting was made on September 7, and the second, 2 weeks later. The randomized block design with five replications was used. Each plot consisted of a single row 10 feet long, spaced 42 inches apart. Sprays were applied by means of compression-type hand sprayers at 40 to 60 psi. Initial sprays were applied at the first-true-leaf stage, and repeated at 5-day intervals. In order to induce disease development in the September 7 planting, a coarse spray of water was applied to the seedlings, and on another occasion a suspension of the disease organism was sprayed on the plants in alleyways sepa-

Table 2. Effect of various materials on the severity of late blight, gray leaf spot and gray mold. Indian River Field Laboratory, Fort Pierce, Florida. 1957.

Materials[a]	Concentration pounds per 100 gallons, or parts per million	Late blight[c] Feb. 26	Mar. 6	Mar. 13	Mar. 27	Gray leaf spot[d] Apr. 9	Apr. 15	Gray mold[e] Mar. 18
Check	---	5.4	10.7	11.0	11.0	---[b]	---[b]	---[b]
Manzate	1 1/2 lbs.	1.4	4.1	4.0	5.8	2.0	3.5	5.0
Parzate	2 lbs.	1.0	4.1	4.8	7.8	2.0	3.8	5.5
Parzate (nabam)-zinc sulfate	2 qts. -3/4 lbs.	1.5	4.3	5.0	8.8	1.5	4.3	5.3
Phygon XL	3/4 lbs.	1.8	5.7	6.0	8.8	4.8	7.0	0.3
Fermate	3 lbs.	3.0	9.1	10.5	---[b]	---[b]	---[b]	---[b]
Thylate	1 1/2 lbs.	4.4	9.5	10.0	---[b]	---[b]	---[b]	---[b]
Vancide 51-zinc sulfate	2 qts. - 1 lb.	3.1	8.4	9.8	---[b]	---[b]	---[b]	---[b]
Tennan #5	2 lbs.	4.9	8.5	8.8	---[b]	---[b]	---[b]	---[b]
Thioneb-50W	2 lbs.	2.4	6.3	8.0	---[b]	---[b]	---[b]	---[b]
Parzate-Phygon	1 1/2 lbs. -1/2 lb.	1.0	3.5	4.3	7.5	4.3	5.0	1.8
Parzate-Thylate	1 1/2 lbs. -1 lb.	1.5	3.7	4.5	7.0	1.8	3.0	1.3
Parzate-Fermate	1 1/2 lbs. -2 lbs.	1.8	4.4	5.0	8.3	2.3	3.5	1.3
Dyrene	3 lbs.	2.0	6.5	8.0	---[b]	---	---	---
Phygon-Dyrene	1/2 lb. - 2 lbs.	1.1	4.8	5.5	8.3	1.5	2.0	0.0
Parzate-copper-Agrimycin	2 lbs. -3 lbs. -100 ppm	1.3	5.7	5.8	9.5	4.5	6.3	1.3
Phygon-copper-Dyrene-Agrimycin	1/2 lb. -3 lbs. -2 lbs. 100 ppm	1.2	4.1	4.0	7.3	0.8	1.0	0.3
Omadine-Zinc salt	2 lbs.	3.4	9.0	10.3	---[b]	---[b]	---[b]	---[b]
L.S.D. .05		1.5	1.4	1.4	1.2	0.8	0.8	1.6
.01		2.0	1.9	1.8	1.6	1.1	1.1	2.1

[a] Active ingredients of materials not listed under footnote (a) table 1: Manzate, 70% maneb; Parzate, 65% zineb; Parzate (liquid), 19% nabam; Phygon XL, 50% dichlone; Fermate, 76% ferbam; Thylate, 65% thiram; Vancide 51, 30% sodium salts of dimethyldithiocarbamic acid and 2-mercaptobenzothiazole; Tennan #5, 70% manganous dithiocarbamate, Thioneb 50-W, 50% polyethylene thiuram sulfide; Omadine, 50% 2-pyridinethione 1-oxide; Dyrene, 50% 2, 4-Dichloro-6-(0-chloroanaline) Triazine.

[b] Plots destroyed by late blight. [c] Scored on a 0-11 basis where 11 equals complete defoliation. [d] Scored on a 0-7 basis where 7 equals maximum severity. [e] Scored on a 0-6 basis where number represents number of plants diseased.

rating plots. As a result the disease became well established.

Results: Bacterial spot developed to serious proportions in both tests (Table 1). Three things of particular significance are noted: 1) failure of streptomycin formulations to provide appreciable control, 2) the significant degree of control provided by copper alone, and 3) the additive effect between some of the streptomycin formulations and copper which has been noted on celery and pepper (4, 5, 6). The disease severity spread between streptomycin plus copper plots on the one hand, and the untreated check on the other in the present work (Table 1) provides a striking demonstration of control. Agrimycin-100 and Agristrep performed equally well, both when used alone, or when in mixture with copper.

Spring Test (Fungicides)

Materials and Methods: A randomized block design with four replications was used. Each plot consisted of two 18-foot rows; one set with Manalucie plants and the other with Homestead-2 on January 11, 1957. Plot rows were isolated by means of a guard row on either side. Materials were applied with a hand controlled broom attached to a power sprayer developing 300 psi. Half of each guard row was sprayed with the test material used on the adjacent plot row. Depending on plant size, the number of nozzles per row ranged from three to eight, with a corresponding gallonage-per-acre of 50 to 200. Sprays were applied on a 3 to 5 day schedule, depending on the weather conditions. Twenty applications of fungicides were made during the period, January 16 to April 5. Heavy rains occurred on February 25, 27, and March 4, 5, 6, 7. Standard cultural practices and insecticide spray programs were employed in all cases.

Results: Information was obtained on the control of late blight, gray leaf spot and gray mold.

A. Late Blight: Late blight was by far the most serious disease during this test. In fact, one of the worst epiphytotics in the history of tomato production occurred in many areas of south Florida during the spring of 1957. This can be noted in Table 2, where by March 13 every plant in the check plots was dead. Table 2 also reveals the fact that the ethylene bis-dithiocarbamate materials (maneb, zineb, and nabam plus zinc sulfate) provided better control than any other material. It is also interesting to note that maneb held the disease more effectively than zineb, while the latter, in turn, appeared to be more effective than nabam. Another observation was that dichlone did not provide control equal to that of maneb or zineb. It is also apparent that several materials showed considerable effectiveness during the forepart of the season, only to fail completely during the latter part.

Certain combinations of materials were quite effective. For example, zineb (1 1/2 pounds per 100) and thiram (1 pound per 100) in mixture were equally--if not more -- effective than zineb (2 pounds per 100) used alone. Zineb-dichlone-Dyrene, and dichlone-neutral copper-Dyrene-Agrimycin mixtures all provided degrees of control comparable to that of zineb alone.

B. Gray Leaf Spot: Gray leaf spot appeared rather early in the season on the Homestead variety (Manalucie is practically immune to gray leaf spot) and gradually built up through April. Because of the ravages of late blight, readings were not obtained on many of the plots (Table 2). Nevertheless, important information was obtained on performance of several of the materials alone and in mixture. Plots sprayed with Dyrene exhibited best control. This is in agreement with earlier work by Coe and Conover (1). Maneb, zineb, and nabam-zinc sulfate provided intermediate degrees of control as did zineb-ferbam mixtures. Dichlone was least effective. (Note: since check plots had been destroyed, it was not possible to determine the exact degree of control.) It also appeared that dichlone decreased the effectiveness of zineb against gray leaf spot when these two materials were used in mixture. The rating for plots sprayed with a mixture of these was an intermediate of each when used alone. This suggests a degree of incompatibility between dichlone and zineb, or is the result of the reduced dosage of zineb in the mixture.

C. Gray Mold: Plots were inoculated February 15 in a manner similar to that described before (7). The first sporulating gray mold lesions were found February 26. Exceptionally wet, cool weather prevailed during the following 6 weeks. Unfortunately, many of the plots were completely destroyed by late blight during that period. In spite of the apparently favorable weather, gray mold failed to develop as rapidly and to the extent expected in the surviving

plots. Disease readings were obtained March 18. Results are shown in Table 2.

In general, the results are in agreement with those of the previous year (7). Dichlone again provided superior control; whereas, disease incidence was highest in the maneb, zineb, and nabam-zinc sulfate plots. Disease incidence was intermediate in plots sprayed with zineb in mixture with dichlone, thiram or ferbam. It is interesting to note that not one lesion was found in plots sprayed with a mixture of dichlone and Dyrene.

D. Phytotoxicity: Because of the severity of diseases it was difficult to detect spray injury. However, nabam-zinc sulfate caused moderate injury in the form of a yellow mottling of the leaves and stunting of the plants. The copper plus Agrimycin plus Dyrene plus dichlone treatment resulted in light to moderate crinkling or distortion of the leaves. In more recent work[2], both Dyrene and dichlone, alone and in combination, caused injury to tomato seedlings during hot weather.

DISCUSSION

Several important observations were made during the course of this work that warrant further study. One was the failure of streptomycin formulations to provide appreciable control of bacterial spot. Erratic performance of streptomycin has been noted previously for the same disease on pepper (6), but Conover (2, 3) had obtained consistently good results on tomatoes in the Homestead area.

The possible superiority of maneb over zineb or nabam in the control of late blight is also noteworthy, as is the failure of Dyrene to control late blight under the severe conditions of this test. Since Dyrene showed excellent control of gray leaf spot, it would appear that this material, though not a substitute, has promise as a supplement in the spray program where varieties susceptible to gray leaf spot are used.

From the standpoint of information on control of gray mold, it is unfortunate that many of the plots were destroyed by late blight. From the practical viewpoint, however, it emphasizes very forcibly the earlier statement to the effect that control of one disease may be of no avail unless adequate precautions are taken against the others. Nevertheless, evidence was obtained that tended to confirm previous work (7), that use of the ethylene bisdithiocarbamate fungicides (maneb, zineb, nabam) not only failed to control gray mold but actually resulted in increased incidence.

The final test of experimental findings in agricultural research is "field performance" under commercial conditions. The suggested spray program based on this work (8) "stood up" under such tests during the 1956-57 growing season on Rauth's Staked Tomato Farm, Delray Beach, Florida. It is emphasized that the carbamates were practically eliminated from the spray program until the "Botrytis season" was well passed. Bacterial spot appeared in several locations on this farm. Spread from these initial loci was very limited. It was apparent that the copper-streptomycin spray effectively held it in check, since in replicated trials involving 1/2-acre plots, the value of the streptomycin-copper combination for bacterial spot control was clearly demonstrated. For example, the average disease severity on November 16, 1956 in plots sprayed with Agrimycin (100 ppm) plus Tribasic Copper Sulfate (4 pounds per 100) was 1.0 (scored on a 0 to 11 basis), whereas, the ratings for plots sprayed with Parzate, Fermate, Phygon and Thylate were respectively, 4.0, 4.2, 3.8 and 4.0. Perhaps more striking, however, was the almost total absence of Botrytis gray mold which had been present in epiphytotic proportions on this farm for the past 4 years. Only an occasional lesion was found in the entire planting at any given time, while on a farm 2 miles to the north where zineb and maneb were used, the disease became well established.

Literature Cited

1. COE, D. M., and R. A. CONOVER. 1956. B-622 as a control for gray leaf spot of tomato. Plant Dis. Reptr. 40: 1084-1086.
2. CONOVER, R. A. 1954. Control of bacterial spot of tomato and pepper seedlings with Agrimycin. Plant Dis. Reptr.

[2] This unpublished research was completed by R. E. Stall, Assistant Plant Pathologist, Indian River Field Laboratory.

38: 405-409.

3. CONOVER, R. A. 1955. Control of bacterial spot in tomato fields with streptomycin-Terramycin sprays. Plant Dis. Reptr. 39: 611-615.
4. COX, R. S. 1955. Compatibility between a streptomycin-Terramycin formulation and copper in the control of bacterial blight of celery. Plant Dis. Reptr. 39: 484-486.
5. COX, R. S. 1955. Compatibility between streptomycin and copper in the control of bacterial spot of pepper. Plant Dis. Reptr. 39: 616.
6. COX, R. S. 1957. Additive effect of Agrimycin and copper in the control of bacterial spot of pepper (Abst.) Phytopathology 47: 6-7.
7. COX, R. S., and N. C. HAYSLIP. 1956. Progress in the control of gray mold of tomato in south Florida. Plant Dis. Reptr. 40: 718-726.
8. COX, R. S., and N. C. HAYSLIP. 1957. Control of the major foliage diseases of tomatoes grown on the sandy soils of south Florida. Fla. Agri. Expt. Sta., Indian River Field Lab. Mimeo. Rept. 57-3.

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THE RUST REACTION OF TROPIC WONDER AND SEVERAL OTHER POLE BEANS FOR THE TROPICS

T. Theis, L. Calpouzos, and E. Cabanillas

A new pest-resistant pole bean, Tropic Wonder, was developed recently (3). This new variety, in addition to having quality and good production, was reported to be resistant to many races of rust caused by Uromyces phaseoli var. typica Arth. Resistance to this disease is an important trait for pole beans in the Tropics since long periods of high humidity are frequently encountered. These conditions are favorable for rust infections (2). After the Tropic Wonder bean was released for distribution, evidence was obtained that it is susceptible to rust.

The new variety was distributed to many places for trial with the request that comments be made about its performance. Three replies were received [1], and two of these (Mr. Jordán in Puerto Rico, and Mr. Fernández in Argentina) reported that Tropic Wonder was highly susceptible to rust. There was no information from Santo Domingo with regard to rust reaction, but they did report that 18 percent of the plants were infected with mosaic.

At the Federal Experiment Station, Mayaguez, Puerto Rico, field plantings were made during November, December, and January 1956-57, to increase seed. In each of the three plots, a severe rust infection occurred when the plants were young and continued until they were mature.

Tests were conducted in the greenhouse to determine the type of rust reaction of Tropic Wonder and to compare it with other varieties. Three plants per 4-inch pot were inoculated at the three-leaf stage by dusting with a mixture of talc and bean rust spores. The spores were freshly collected from diseased Tropic Wonder plants in the field. The inoculated plants were incubated in a mist chamber for about 10 hours, allowed to dry for several hours, and then transferred to a greenhouse bench. The reaction to rust was determined using the scale developed by Wei (4).

The following bean varieties were tested: Tropic Wonder; Hawaiian Wonder, a rust-resistant pole bean (1); Lualualei, an important commercial bean in Hawaii prior to 1937, very susceptible to some races of rust (1); and Bonita, a bush bean grown commonly in Puerto Rico for dry beans. Two tests were conducted using eight pots of each variety. In both tests, the Hawaiian Wonder and Lualualei plants had a Type 1 infection which consisted of small uredia located in the center of necrotic spots. The Tropic Wonder and Bonita plants had a Type 4 infection with large uredia; secondary sori were produced 6 to 8 days after the appearance of the primary sori.

These results show that, contrary to a previous report (3), Tropic Wonder is very susceptible to bean rust. The Bonita variety is also susceptible. The data suggest that Hawaiian Wonder and Lualualei may be resistant to the races of bean rust present in Puerto Rice. This possibility should be checked by additional tests using rust collections from all over the Island, since the existence of many physiologic races is common (5).

Literature Cited

1. FRAZIER, W. A., and J. W. HENDRIX. 1949. Hawaiian Wonder. Univ. Hawaii, Agr. Expt. Sta., Circular 28.
2. HARTER, L. L., C. F. ANDRUS, and W. J. ZAUMEYER. 1935. Studies on bean rust caused by Uromyces phaseoli typica. Jour. Agr. Res. 50: 737-759.
3. SPENCER, J. L., and W. C. KENNARD. 1956. The Tropic Wonder. Southern Seedsman 19: 24-25.
4. WEI, C. T. 1937. Rust resistance in the garden bean. Phytopathology 27: 1090-1105.
5. ZAUMEYER, W. J., and H. R. THOMAS. 1957. A monographic study of bean diseases and methods for their control. U. S. Dept. Agr. Tech. Bul. 868.

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DISEASES OF SUNFLOWERS IN URUGUAY[1]

W. E. Sackston[2]

Summary

The most widespread and destructive sunflower disease observed in field surveys in Uruguay in 1956-1957 was rust (Puccinia helianthi). Other previously recorded diseases observed were white rust (Albugo tragopogonis), head rot (Sclerotinia sclerotiorum), root rot and wilt (Sclerotinia minor and Sclerotium rolfsii), and peste negra (cause under investigation). Sunflower diseases reported for the first time in Uruguay were: leaf mottle (Verticillium albo-atrum), downy mildew (Plasmopara halstedii), black root rot (Sclerotium batatícola), wilt and root rot (Fusarium oxysporum), powdery mildew (Erysiphe cichoracearum), leaf spot (Itersonilia perplexans), head drop (cause unknown), bud blight (cause unknown), and mosaic (virus).

Sunflowers in Uruguay are a summer crop, commonly sown in October or November. Some late seedings are made in early December, and a "second" crop, following winter wheat, is often sown in late December or early January. In 1956 the spring rains were followed by a disastrous drought, extending from late October to early February. Sunflowers sown at the regular time suffered severely; those sown late emerged irregularly or failed to emerge, and practically no "second" seeding was done after the wheat harvest. Yields were generally low, in part as a result of the drought and intense heat of the summer, but also as a result of severe disease infections.

Observations on diseases were made during several survey trips. The first of these, in the neighborhood of La Estanzuela in the department of Colonia, was made on January 11, 1957. Plant development varied greatly from field to field. In some fields the plants were about 1/2 meter tall, in others they were from 1 1/2 to almost 2 meters, and starting to bloom. Seventeen fields were examined. A second trip was made, between January 28 and February 2, along the Uruguay River in the west, north to the southern portion of the department of Artigas. Fifty-one fields were examined: in some, the plants were seedlings of late or "second" sowings; in most, they were in early bloom to middle bloom; and in three fields north of Salto, they were ripe. Forty-two fields in the center, north, and east of Uruguay were examined between February 11 and February 21. The plants were in various stages, but tended to be more mature, in late bloom or finished blooming. Several additional fields were examined as opportunity offered.

Rust (Puccinia helianthi Schw.)

Rust was the most destructive of the sunflower diseases observed. Outbreaks of sunflower rust in Uruguay do not seem to be of local origin. Infections arising from overwintered teleutospores are rare, it they occur at all. Pycnia and aecia were observed on leaves almost covered with teleutosori in plots at La Estanzuela in July 1956. They were observed again on rusted leaves in a few farm fields in March 1957. Apparently freshly formed teleutospores may germinate and induce pycnial infections on mature leaves. Pycnial and aecial infections were not found on volunteer seedlings or on plants in experimental plots in which sunflowers had been heavily rusted the previous year.

Rust was hard to find on January 11. A few pustules were seen in three of the fields examined, and one or two pustules were found on most of the plants in a fourth field. Rust had not yet been observed in experimental plots at La Estanzuela on this date. By the end of January rust was present in all but two of the fields examined during the survey. Infections were light to moderate in most fields, and heavy, with 60 percent of the leaf surface affected, in three fields north of Salto. All three fields were prematurely ripe, partly as the result of drought, and partly as the result of the severe rust infection. Infections were remarkably uniform in

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most fields. In some fields the lower leaves were more heavily rusted than the upper ones, indicating early infection, when the plants were smaller, followed by local spread. In other fields, however, infections were fairly uniform from top to bottom leaves, apparently arising from heavy spore showers when the plants had reached their maximum development. The sunflowers and the rust were more advanced in the survey made from the 11th to the 21st of February. Heavy infections were seen in 14 fields from Tacuarembo east to Melo, in the north, and from Melo north to the Brazilian border; and in two fields south of Treinta y Tres. The heavily rusted plants were in full bloom to just past bloom. Severe rust attack at this critical stage has been shown to result in greatly reduced yields of seed. Isolation from other sunflower fields did not seem to lessen rust infection. One of the heavily rusted fields was in a grazing area, on land cropped for the first time, about 40 kilometers from the nearest sunflower field seen.

Rust infection developed rapidly in plots at La Estanzuela. A few uredial pustules were present on some plants by January 21. By February 6 rust infection was general; about 20 percent of the surface of leaves half way up the stem and about 5 percent of the surface of upper leaves was attacked. By February 25 rust infections were heavy. The uniformity of infection and the speed with which the disease developed provide additional evidence that it originated from air-borne spores deposited in great numbers. The source of this inoculum seems to be Argentina. The wind frequently blows from the west; the sunflower area in Argentina is large, considerably more than 1,000,000 hectares, and the supply of rust spores is proportionally large. The source of inoculum for rust outbreaks in the important sunflower area in the province of Buenos Aires, in Argentina, is not known. Pycnia and aecia occur scarcely, if at all, in farm fields of sunflowers in Argentina, and uredial infections appear as suddenly and as uniformly as in Uruguay, although slightly earlier. The inoculum may come from early plantings in the north of Argentina; the occurrence, at the time of the surveys, of the heaviest rust infections in the north of Uruguay may support this possibility.

Several fields in the neighborhood of La Estanzuela which were free of rust on January 11 were visited again on March 5. Leaves were dead and teleutospore infections ranged from 60 to 70 percent on most plants. The plants were prematurely ripe in most fields; some of the injury was due to drought and other causes, but some of it was the result of the extremely heavy rust infection.

Leaf Mottle (Verticillium albo-atrum Reinke & Berth.)

Leaf mottle, not previously recorded in South America[3], was found in more than half the sunflower fields examined in survey trips in Uruguay and several specimens were also collected in Argentina. The characteristic symptom is necrosis of the interveinal areas of the leaves; necrosis also occurs at leaf apices and along the margins. Symptoms appear first on basal leaves and progress upwards along the stem. Plants attacked very early may wilt and die; those attacked at the flowering stage may ripen prematurely, with a consequent reduction in seed yield. Although Verticillium albo-atrum has not been recorded previously in Uruguay, it seems to be widespread in the soil. The native hosts of the pathogen in Uruguay are not known. It is possible that Eupatorium buniifolium Hook. & Arn., an extremely common shrub in pastures and along fences, is one of its hosts, although the fungus was not recovered from wilted plants. Typical leaf mottle symptoms were observed on Xanthium cavanillesii Schouw, an introduced weed, in sunflower fields and the pathogen was isolated from affected plants. The fungus attacks many different hosts in many parts of the world, including Argentina. An important host is cotton and it is possible that verticillium wilt of cotton will appear in Uruguay.

Leaf mottle infection varied from traces to 1 or 2 percent in 54 fields. Between 5 and 10 percent of the plants were attacked in five fields, from 15 to 25 percent in five fields, 35 percent in two fields, 50 percent in one field and 80 percent in one field. It proved possible to question several growers whose crops were severely attacked; in most cases sunflowers had been grown for a number of years in the same field. In one exceptional case, sunflowers had been sown in the same field for 13 consecutive years. In one field in which sunflowers were the

[3]The pathogens and diseases of sunflowers described as "not previously recorded in Uruguay" are those that are not included in the publication by Lucia Koch de Brotos and Celia Boasso, "Lista de las enfermedades de los vegetales en el Uruguay", Publicacion No. 106, Direccion de Agronomia, Ministerio de Ganaderia y Agricultura, 1955, Montevideo, Uruguay, and which Sra. de Brotos and Srta. Boasso had not encountered subsequent to the publication of their check list.

first crop after plowing a pasture heavily infested with Eupatorium buniifolium, 25 percent of the plants showed leaf mottle symptoms. In an adjacent field, in which sunflowers had been grown several times, 80 percent of the plants were affected.

White Rust (Albugo tragopogonis (Pers.) S. F. Gray)

White rust was seen in about two-thirds of the fields examined. Infections were very light in most fields, but about 5 to 10 percent of the leaf area was affected in a number of fields, and 25 percent infection was noted in one small field, on small plants of the "second" crop. Spores of the pathogen are apparently wind borne, as infections occurred on plants in a screened shelter, but dissemination may not take place over such great distances as with Puccinia, as plants in isolated fields were free or relatively free of the disease. The disease is not considered important in most years, but under favorable circumstances it can cause severe injury. White rust was relatively severe on the first true leaves of volunteer seedlings and on plants in experimental plots at La Estanzuela. It was less conspicuous later in the season, probably because of the drought.

Downy Mildew (Plasmopara halstedii (Farl.) Berl. & De T.)

Downy mildew, not previously recorded on sunflowers in Uruguay, was found in 15 fields. There were traces of the disease in ten fields, 5 to 10 percent in two fields, and 25 to 35 percent in three fields. One of the light infections was seen near Dolores, in Soriano, and another near Lascano, in Rocha; all the other affected fields were in the department of Colonia.

In Uruguay as in Manitoba in Canada downy mildew seems to be exclusively soil-borne. All the affected plants showed systemic infection. They were stunted to various degrees, heads were erect instead of nodding, there was a characteristic pattern of chlorosis along the leaf veins, and in a few specimens the pathogen was fruiting on the lower surface of the leaves in the area corresponding to the chlorosis on the upper surface. No secondary infections were observed on any leaves.

The grower in whose field 35 percent infection of downy mildew was found has noticed the disease for several years. He has alternated sunflowers and barley in that field for 15 years. The localization of the disease in Colonia may be due to the intensive cropping of sunflowers in that department, with very short rotations, which favors the spread of the pathogen from the original foci of infection. It is not known how or when the disease was introduced originally. A very low incidence of seed-borne infection has been reported. As the disease is known in most sunflower growing countries, it is most probable that the fungus came with sunflower seed from an infested region.

Head Rot (Sclerotinia sclerotiorum (Lib.) d By.)

Head rot was severe at La Estanzuela in July 1956, in sunflower plots sown in March; about 35 percent of the heads were destroyed by the fungus. The disease was not observed in farm fields during the disease surveys, but one head was affected in a screened shelter in April, 1957. Head rot apparently is severe in years when early rains delay harvesting, especially in late-sown sunflowers and in the "second" crop. No specimens of root rot or wilt induced by this pathogen were found, although it caused stem rot of a few plants. In some other countries, sclerotia left in the field after harvest of affected sunflowers produce mycelium that attacks the roots of subsequent crops. This apparently did not occur in Uruguay in 1956-1957, although the pathogen caused root rot and wilt in experimental inoculations. Sclerotinia sclerotiorum in Uruguay forms apothecia readily. Sclerotia buried in soil in pots in a screened shelter in August 1956 produced many apothecia after some cool, wet weather in April 1957.

Wilt and Root Rot (Sclerotinia minor Jagger, Sclerotium rolfsii Sacc.)

Wilted and dead plants, with the roots or base of the stem attacked by Sclerotinia minor, were found in six fields in the course of disease surveys. Infections ranged from trace to 1 percent of the plants. Five of the fields were in the department of Colonia and one in Soriano. The same pathogen was isolated from wilted and dead volunteer plants, and from plants in experimental plots, in an area in which sunflowers were grown in 1955-1956.

Wilted and dead plants attacked by Sclerotium rolfsii were found in seven fields. Four of the fields were in Colonia, two in San José, one in Durazno, and one in the south of Lavalleja.

Infections ranged from trace to 1 percent of the plants.

Black Root Rot (Sclerotium bataticola Taub.)

Dead plants, stunted, black, and with an extremely restricted root system, were found in some of the fields examined during survey trips. The roots were dark externally and usually gray to greenish-gray internally, whereas healthy plants had vigorous roots, pale externally and white internally. The plants apparently had been affected by root rot early in their development. Sclerotium bataticola was isolated regularly from such specimens. Larger, prematurely ripe and dead plants were also found in a number of fields in which healthy plants were still in bloom. The stems of affected plants were pale to dark brown, and the base of the stems was very dark brown to black. The roots were small, dry, and usually gray internally. S. bataticola was isolated from the roots of these plants also. This pathogen has not previously been reported on sunflowers in Uruguay. Affected plants were found in 28 of the fields examined. Only a few plants were diseased in most of the fields; from 1 percent to 10 percent of the plants were affected in five fields. Similar symptoms were observed in volunteer plants and in experimental plots at La Estanzuela, and the same pathogen was isolated.

Fusarium Wilt and Root Rot (Fusarium oxysporum Schlecht.)

Fusarium oxysporum was isolated from the roots of many sunflower plants killed by root rot. In a few cases it was the only organism isolated. In a few cases it was associated with Sclerotinia minor. In many cases it was intimately associated with Sclerotium bataticola, the two fungi often growing from the same piece of tissue. In experimental inoculations in the greenhouse pure cultures of each of the three fungi caused root rot and wilt of sunflowers. The symptoms induced by the respective pathogens were not identical. F. oxysporum has not previously been reported on sunflowers in Uruguay.

Peste Negra (Cause under Investigation)

Peste negra as described in the literature was seen in very few fields and on very few plants at the time of the surveys. It is typically a disease that appears as the crop is maturing; the survey trips were made when the sunflowers were still in bloom in most fields. Typical symptoms were observed on a few volunteer plants and on some plants in experimental plots at La Estanzuela in February. Plants left unharvested showed peste negra in May. The disease was encountered in most of the fields examined in Argentina in the last 2 weeks of March. It is probable that it would have been found generally in Uruguay as well if it had been possible to make a late survey.

The main effect of peste negra, apart from its symptoms, is to induce premature ripening and consequent reduction in seed yield. The severe drought and heavy rust infection in 1956-1957 also induced premature ripening and a great reduction in seed yield. It is quite probable, therefore, that the effects of peste negra were obscured in Uruguay this season and that symptom expression was inhibited by the dry weather.

Powdery Mildew (Erysiphe cichoracearum DC.)

Powdery mildew was present at La Estanzuela in July 1956 on leaves and stems of sunflowers in a field plot sown in March. The disease also occurred on seedling plants in the greenhouse. It was not seen in farm fields. Powdery mildew has not previously been recorded on sunflowers in Uruguay.

Leaf spot (Itersonilia perplexans Derx)

A leaf spot of the cotyledons and first leaves of sunflowers was observed in plants inoculated with rust in the greenhouse at La Estanzuela, and was also found on volunteer seedlings in one plot. The pathogen, Itersonilia perplexans, occasionally attacks greenhouse sunflowers in Manitoba, Canada. It has not previously been reported from South America.

Head Drop (Cause Unknown)

Head drop, apparently a physiological condition of unknown origin, was observed in a number

of fields. The disease is known in Chile and in Canada, but has not previously been reported from Uruguay. The stems of affected plants appear to have been cut with a knife about 10 to 15 cm below the head. Only a few plants were affected in most cases. In one field, in which about 1 percent of the heads had dropped, the affected plants occurred in groups of two or three fairly close to each other.

Bud Blight (Cause Unknown)

A condition not previously reported on cultivated sunflowers, although observed on wild Helianthus spp. in Manitoba, Canada, was found in a number of fields. The buds of otherwise apparently normal plants were blighted, dark gray to almost black, small, and shriveled. One or two leaves immediately below the bud were also dead and black in some cases. The affected plants apparently had continued to grow after the buds were blighted. The stems were green, the roots white and well developed, and there was no vascular discoloration.

Mosaic (Virus)

A few plants with symptoms of virus mosaic were observed in experimental plots at La Estanzuela and in three farm fields.

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THE EFFECT OF GIBBERELLIN ON PLANT DISEASE

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Previous investigations (3, 4, 5) demonstrated that various plant growth regulators (PGR) induce resistance to Fusarium wilt of tomato. However, the PGR had to be applied prior to inoculation or their effect on disease resistance was not significant. It was hypothesized that the resistance to Fusarium wilt imparted by the PGR was due to changes induced in the metabolism of the host rather than to any inherent fungitoxic properties of the PGR. The gibberellins are known to affect profoundly many physiological processes in plants (1, 6, 7, 9). Accordingly, we examined the effect of the potassium salt of gibberellic acid on resistance to diseases caused by members of the three major classes of fungi.

With minor modifications, the method and materials described by McCallan and Wellman (8) was used in the early blight (Alternaria solani) and late blight (Phytophthora infestans) tests on tomato. The upper leaf surfaces of 7- to 8-leaved tomato plants (Lycopersicon esculentum var. Bonny Best) were sprayed with a 20 ppm solution of potassium gibberellate containing 0.05 percent Tween 20. Treatments were applied on one set of plants 5 days prior to inoculation and on another set of plants 4 hours prior to inoculation. The lower leaf surface was inoculated with spore suspensions containing either 40,000 spores per ml of A. solani or 50,000 sporangia per ml of P. infestans. More than 50 percent of the sporangia had germinated by zoospore formation just prior to inoculation. The Pinto variety of bean (Phaseolus vulgaris) was used in the rust (Uromyces phaseoli var. typica) test. The lower leaf surface of the first trifoliate leaf was inoculated with a spore suspension of 80,000 uredospores per ml. One-hundredth of a ml of a 50 ppm potassium gibberellate solution containing 0.05 percent Tween 20 was applied in the axils of the primary leaf. The sequence of treatment and inoculation was the same as described in the tomato disease assays. The first trifoliate leaf was just beginning to expand at the time the first set of plants was treated. Inoculated plants were incubated for 24 hours at 20° C and 100 percent relative humidity. Disease readings on early and late blight were made 3 days after inoculation, while bean rust lesions were counted 7 days after inoculation.

Table 1. The effect of potassium gibberellate on disease susceptibility.

Disease	Experiment number	Number lesions per leaf[a]		
		Untreated	Treated at time of inoculation	Treated 5 days prior to inoculation
Early blight	1	245	262	257
	2	233	230	237
Late blight	1	375	340	397
	2	111	160	133
	3	223	190	270
Bean rust	1	600	520	230
	2	526	616	675

[a]The early and late blight indices were derived from the 4th, 5th, and 6th leaves above the basal leaf, while the bean rust index was derived from the first trifoliate leaf.

The data in Table 1 demonstrate that susceptibility of tomato to early blight was not affected by potassium gibberellate, whether treatment was applied 5 days prior to or at the time of inoculation. The response to late blight was more variable, but there was no appreciable change in susceptibility. The results with bean rust are anomalous. In one experiment resistance to rust was markedly increased when treatment preceded inoculation, while in a second experiment there was a slight increase in susceptibility.

The variable response of gibberellin treated bean plants to rust infection can be explained by the modifying influence of various environmental factors on the growth response of plants to gibberellin treatment. Light, temperature, stage of plant development may indirectly alter

the effect of gibberellin on plant growth (2, 6, 7, 9). Accordingly, in evaluating alterations in disease susceptibility caused by gibberellin, it is necessary to consider the particular environmental conditions prior to treatment, at the time of treatment, and during the remaining growth period.

Literature Cited

1. BRIAN, P. W., and H. G. HENNING. 1955. The effect of gibberellic acid on shoot growth of pea seedlings. Physiologia Plantarum. 8: 669-681.
2. CATHEY, H. M., and N. W. STUART. 1957. Growth and flowering of Chrysanthemum morifolium Ramat. as affected by time of application of gibberellic acid. Submitted for publication to Proc. Amer. Soc. Hort. Sci.
3. DAVIS, D. 1952. Chemotherapeutic activity may be independent of fungitoxicity. Phytopathology (Abst.) 42: 6.
4. DAVIS, D., and A. E. DIMOND. 1952. Altering resistance to disease with synthetic organic chemicals. Phytopathology 42: 563-567.
5. DAVIS, D., and A. E. DIMOND. 1953. Inducing disease resistance with plant growth regulators. Phytopathology 42: 137-140.
6. LANG, A. 1956. Induction of flower formation in biennial Hyoscyamus by treatment with gibberellin. Naturwiss. 42: 284-285.
7. LOCKHART, J. A. 1956. Reversal of the light inhibition of pea stem growth by the gibberellins. Proc. Nat. Acad. Sci. 42: 841-848.
8. McCALLAN, S. E. A., and R. H. WELLMAN. 1943. A greenhouse method of evaluating fungicides by means of tomato foliage diseases. Contribution Boyce Thomp. Inst. 13: 93-134.
9. WITTWER, S. H., and BUKOVAC, M. J. 1957. Gibberellins, new chemicals for crop production. Mich. State Agr. Exp. Sta. Quart. Bul. 39: 1-28.

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CYTOSPORA CANKERS OF COTTONWOOD

Ernest Wright

Cytospora has been frequently observed on various species of broad-leaved ornamental and forest trees. C. chrysosperma (Pers.) Fr. (Valsa sordida Nits.) is commonly associated with cottonwoods and willows. In the Great Plains area during the drought years of the mid-thirties, C. chrysosperma was particularly abundant on cottonwoods (Populus deltoides) in shelterbelts[1].

The written evidence definitely indicates that C. chrysosperma is not a virulent parasite but is a disease of trees in declining vigor[2]. The observations presented here tend to confirm this statement.

SHELTERBELT STUDIES

Shelterbelts are much better watered than normal precipitation records of the Great Plains region indicate because of the accumulation of windblown snow. However, unless cottonwoods are planted on favorable sites they are still susceptible to drought injury, and Cytospora cankers become common. Sites with shallow soil dry out readily and are further depleted by the extensive development of surface roots of cottonwoods in quest of moisture.

Comparison of two 5-year-old shelterbelts near Orchard, Nebraska shows this relation between vigor and occurrence of Cytospora. The plantations were only about a half mile apart, so difference in precipitation was not a factor.

In the good shelterbelt, the trees were growing on deep sandy soil with an abundance of subsoil moisture. Feeding rootlets were 3 to 8 inches deep. Lateral roots extended for 20 feet. Some of these trees had developed twin taproots that penetrated to a depth of 10 feet. Commonly there was a secondary tier of laterals at a depth of 3 feet (Fig. 1). On this moist site, the tips of the lateral roots turned downward to a depth of 14 inches. These cottonwoods grew vigorously and were 5 to 6 inches in diameter at the ground and over 20 feet tall. Foliage was luxurious. No Cytospora cankers or fruit bodies were found on any of these trees.

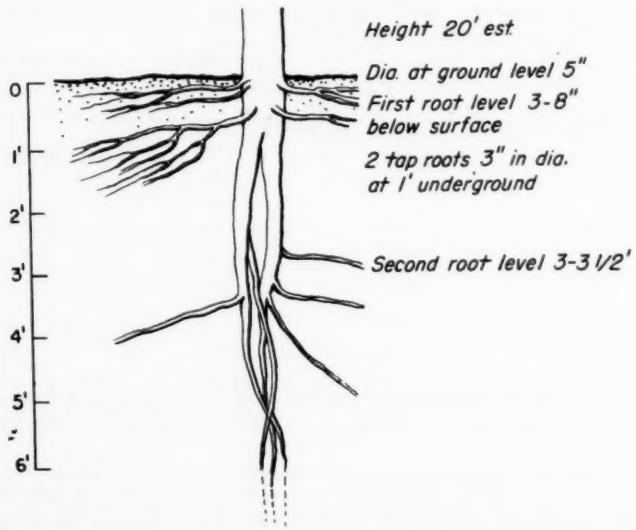

FIGURE 1. Diagram showing the profuse development of cottonwood roots in a deep sandy soil with an abundance of subsoil moisture; 5-year-old plantation.

[1] Baxter, D. V. 1952. Pathology in forest practice. Ed. 2, 601 pp., illus. New York and London.
[2] Christensen, C. M. 1940. Studies on the biology of Valsa sordida and Cytospora chrysosperma. Phytopathology 30: 459-475.

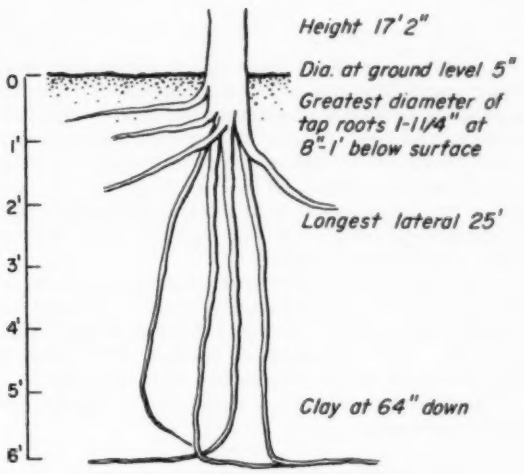

FIGURE 2. Diagram of cottonwood root development in a sandy loam soil with a clay hardpan at 6 feet and restricted subsoil moisture; 5-year-old plantation.

In the poor shelterbelt, the cottonwoods were planted with the same 6-foot spacing on a shallow loamy soil with a clay hardpan about 6 feet below the surface. These trees had no well-defined taproot (Fig. 2). Numerous lateral roots had developed at a depth of 8 inches and extended in all directions as far as 25 feet. The lateral roots frequently turned upward at the tips in search of surface moisture. On this poor site the cottonwoods were 3 to 4 inches in diameter at the ground and 15 to 17 feet tall. These trees grew vigorously for a year or two and then developed thin foliage typical of cottonwoods in distress. Numerous Cytospora cankers were found in this plantation, which assisted materially in killing many of the trees. In addition, dying and dead trees developed myriads of typical reddish-orange spore tendrils. In many instances no definite cankers were formed but the cambium of the main bole was definitely necrotic. Drought apparently was the major factor causing the decline of this plantation and consequent susceptibility to Cytospora.

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A PARTIAL LIST OF FUNGI ASSOCIATED WITH DECAY OF WOOD PRODUCTS IN THE UNITED STATES[1]

Ellis B. Cowling

Identification of the fungi which commonly decay wood products is a prerequisite to development and application of efficient methods of decay control. For this reason, and in view of the growing economic importance of these organisms, it has appeared desirable to present a partial list of these fungi. The present list was prepared by searching the major phytopathological literature of this country for reports of fungi associated with decay of wood products. The publications consulted include the originals of pertinent papers abstracted in the Review of Applied Mycology (vols. 1 to 33) and Biological Abstracts (vols. 14 to 28), recent papers in Phytopathology (vols. 1 to 44), and the texts on forest pathology by Baxter (1952), Boyce (1948), and Hubert (1931).

The data indicate the types of wood products, kinds of decay, types of wood, and the taxonomic group with which some 98 species of fungi have been associated and so reported in the literature examined. The total number of references in which each fungus was reported is also given. For convenience, the fungi have been listed in alphabetical order under the taxonomic grouping to which each has been assigned.

The author cautions the reader to recognize several potential sources of error in interpreting these data:

1. Association of a fungus with decay is not proof that the fungus caused the decay.
2. Fungi which produce durable and conspicuous fruiting structures are more likely to have been reported than those whose fructifications are less conspicuous or durable.
3. The fungi associated with decay of particular products (for example, boats, buildings, and railroad ties) have been studied more thoroughly than others (for example, poles, posts, and piling) so that the data given are more complete for certain products than for others.
4. Studies of the decay flora of wood products have often been restricted to particular geographic regions so that the data given may not be representative of the country as a whole.
5. The number of references in which each fungus was reported should be accepted as only a very tentative index of the relative prevalence of the organisms.

Although this list is admittedly less complete than would be most desirable, it may serve as a more adequate guide than the widely scattered references from which it was drawn. Hopefully, also, it may stimulate the interest of other wood pathologists in the surveys and compilations needed to provide more complete awareness of the identity and relative importance of these fungi.

The data are compiled in Table 1, on the two pages following.

DIVISION OF WOOD PRESERVATION,
FOREST PRODUCTS LABORATORY,
MADISON, WISCONSIN

[1] Part of a thesis entitled "Preservative Tolerances in a Group of Wood-Destroying Fungi", submitted in 1956 in partial fulfillment of the requirements for the degree Master of Science at the State University of New York College of Forestry, Syracuse, New York.

Table 1. Fungi associated with decay of wood products in the United States.

Name of fungus	Number of references	Type brown (B) or white (W)	Decay hardwood (H) or softwood (S)	Association with decay: Products affected (indicated by +)									
				Buildings				Stored lumber and railroad ties	Railroad ties in service	Stored logs and pulpwood	Poles, posts, piling	Mine timbers	Unidentified
				Industrial	Home and farm	Unclassified	Wooden boats						
BASIDIOMYCETES													
Agaricaceae													
Armillaria mellea	3	W	H&S									+	+
Coprinus sp.	1											+	
Lentinus lepideus	10	B	S			+		+	+	+	+		
L. tigrinus	1	W	H	+									
Panus stipticus	1		H					+					
Paxillus panuoides	2		S							+	+		
Pholiota adiposa	3	B	H					+	+				
P. aeruginosa	1				+								
Pleurotus ostreatus	2	W	H							+			+
P. ulmarius	1	B	H									+	
Schizophyllum commune	4	W	H&S	+	+			+	+	+			
Hydnaceae													
Grandinia farinacea	1				+								
Hydnum erinaceus	3	W	H					+	+			+	
Odontia crustosa	1				+								
O. spathulata	1			+	+								
Steccherinum ochraceum	1				+								
Polyporaceae													
Daedalea confragosa	2	W	H						+				
D. quercina	4	B	H				+			+	+		
Fomes annosus	3	W	S									+	
F. applanatus	4	W	H									+	+
F. officinalis	1	B	S										+
Fomes pini	4	W	S					+		+			
F. pinicola	3	B	S							+		+	
F. roseus	11	B	S	+	+	+		+	+	+		+	
F. subroseus	3	B	S			+		+		+			
Gloeoporus conchoides	2		H					+	+				
Lenzites sp.	1	B	H&S									+	
L. berkeleyi	1	B	H						+		+		
L. betulina	4	W	H					+	+				
L. protracta	1	B							+				
L. saepiaria	13	B	S	+	+	+	+	+	+	+	+		
L. trabea	12	B	H&S	+	+	+		+	+	+	+		
Merulius lacrymans	6	B	S			+		+				+	
Polyporus abietinus	8	W	S					+	+	+			
P. adustus	3	W	H					+		+			
P. alboluteus	1	W	S									+	
P. anceps	4	W	S						+	+			
P. gilvus	1	W	H							+			
P. guttulatus	1	B	S								+		
P. hirsutus	7	W	H					+	+	+	+	+	+
P. pargamenus	4	W	H					+	+	+			+
P. sanguineus	1		H							+			
P. spraguei	1	B	H								+		
P. sulphureus	2	B	H								+		
P. versicolor	10	W	H					+	+	+		+	+
P. zonatus	1	W	H			+							
Poria sp.	3		H										+
P. ambigua	1				+								
P. carbonica	1	B	S				+						
P. crassa	1			+	+								
P. crustulina	1				+								

Table 1 (concluded)

Name of fungus	Number of references	Type brown (B) or white (W)	Decay hardwood (H) or softwood (S)	Association with decay: Products affected (indicated by +)									
				Buildings: Industrial	Buildings: Home and farm	Buildings: Unclassified	Wooden boats	Stored lumber and railroad ties	Railroad ties in service	Stored logs and pulpwood	Poles, posts, piling	Mine timbers	Unidentified
Poria ferruginosa	1	W	H		+								
P. incrassata	5	B	S			+		+					
P. oleracea	1		H				+						
P. monticola	2	B	H&S			+	+						
P. rufa	1	W	H&S		+								
P. simuascens	1				+								
P. simosa	1				+								
P. subacida	1	W	H&S	+	+								
P. vaillantii	4	B	S	+	+								
P. versipora	1			+	+								
P. xantha	4	B	H&S	+	+	+	+			+			
Trametes americana	1		S				+						
T. heteromorpha	4	B	S			+			+	+	+		
T. hispida	2	W	H							+			
T. mollis	1	W	H		+								
T. protracta	2		S	+		+			+		+		
T. sepium	5	B	H					+	+	+	+		
T. serialis	3	B	H&S			+	+	+					
Thelephoraceae													
Coniophora arida	1	B	S								+		
C. cerebella	5	B	H	+	+	+	+	+					
C. olivacea	1		S								+		
C. puteana	2	B	S				+				+		
Corticium sp.	1									+			
C. scutellare	1				+								
Peniophora gigantea	5	B	S			+		+	+	+			
P. pubera	1				+								
Stereum sp.	1												+
S. fasciatum	3	W	H					+	+				
S. frustulosum	1	W	H				+						
S. hirsutum	2		H					+		+			
S. lobatum	2		H					+	+				
S. purpureum	1									+			
S. rameale	2	W	H					+	+				
S. sanguinolentum	4	B	S					+		+			
Tremellaceae													
Exidia glandulosa	1		H					+					
ASCOMYCETES													
Erysiphales													
Orbicula spadicea	1		S	+									
Hypocreales													
Hypocrea citrina	1		H					+					
Sphaeriales													
Chaetomium globosum	1		S	+									
Daldinia concentrica	2	W	H						+				
Hypoxylon sp.	1	W	H										+
H. coccineum	2	W	H					+	+				
H. cohaerens	3	W	H					+	+	+			
Ustulina vulgaris	1	W	H										+
Xylaria polymorpha	1		H										+
FUNGI IMPERFECTI													
Moniliales													
Penicillium brevicaule	1												+
P. glaucum	1												+
Strumella coryneoidea	1		H										+

A SMALL ELECTRICAL HYGROMETER FOR MICROCLIMATE MEASUREMENTS

Marlin N. Rogers[1]

Abstract

A small-sized modification of the Dunmore electrical hygrometer (2 x 12 mm) was constructed and used to make direct relative humidity measurements as near the leaf surface as 0.75 mm. This remote reading instrument removes almost negligible quantities of moisture from the air during use and may be used in still air or in small enclosed spaces. It reaches equilibrium with its environment within 1 to 3 minutes and, with suitable indicating devices, measures relative humidity reliably to an accuracy of 1 percent or better. Full details regarding its construction, calibration, and use are described.

INTRODUCTION

The precision of relative humidity measurements has never remotely approached the exactness of temperature measurements. This probably has been due to two main reasons: 1) the lack of precise, readily obtainable standard relative humidity values for calibration purposes, and 2) the inherent lack of sensitivity in nearly all types of measuring devices so far invented.

The study in process at the time the present instrument was devised was an investigation of the effects of relative humidity at the surface of the leaf upon infection and disease development by several humidity-sensitive pathogens. This, therefore, presented a measuring problem of more than ordinary difficulty.

Earlier workers had attempted to measure differences in moisture at the surface of leaves. MacDougal (12), Livingston (11), Buxton and Mellanby (2), and Ramsey et al. (13) had suggested use of devices whose physical characteristics changed with differences in relative humidity, but none of their instruments had the accuracy, sensitivity, and reliability required for the present work.

Yarwood and Hazen (21) reported that measurements of the temperature depressions resulting from use of green leaves tightly clamped around thermometer bulbs (instead of moistened cotton wicks) could be used for calculation of the relative humidity at the surface of the leaf. Delp (3) attempted to measure the relative humidity by use of a wet thermocouple near the surface of the leaf, but stated, "It was not considered that this method nor any other method found in the literature... was adequate for a precise measure of the humidity in the microclimate of a germinating spore on a transpiring leaf."

Still others have made indirect attempts to determine the relative humidity at the surfaces of leaves. Using the data of Ramsey et al. (13), Frampton and Longree (7) were able to calculate theoretical relative humidity values at zero distance from the leaf, that is, at the surface of the leaf. Shaw (14) and Thut (15) derived values for the relative humidity of intercellular spaces and for stomatal chambers, respectively.

DESCRIPTION OF THE ELECTRICAL HYGROMETER

The instrument devised was based on the principle of the Dunmore electrical hygrometer (5, 6). Reduced to bare essentials, this instrument consisted of two electrodes connected with a hygroscopic salt bridge. As the salt absorbs or loses moisture in equilibrium with the atmosphere to which it is exposed, the electrical resistance of the bridge changes. This can then be measured with suitable measuring instruments. Several other modifications of the Dunmore electrical hygrometer (mainly concerned with reduction in the size of the sensing element) had been reported previously (1, 4, 9, 10, 16). Information dealing with different methods of calibration of such an instrument can be found in papers by Weaver and Riley (18), Wexler (19), Dobrin (4), and Weaver (17).

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[1] The above study was carried out in the Department of Plant Pathology at Cornell University between 1953 and 1956.

Preparation of the Sensing Elements

Thin picture glass 0.04-inch thick was plated on one side with a thin, evaporated rhodium film[2], except for 0.03 inch-wide gaps left at intervals across the plate. These gaps were obtained by stretching pieces of flat-drawn wire tightly across the surface of the glass before plating. The "shadow" cast by the wire during the plating operation gave the desired width gap.

Rhodium was selected as the plating metal for two reasons: 1) it is almost as inert chemically as platinum or palladium, so that long term aging of the hygrometers should not be a problem, and 2) it forms a hard surface that adheres very firmly to the glass. Ordinary polishing will not damage the film, and it is sufficiently adherent so that lead wires could be soldered directly to the film, using ordinary resin-core solder.

The plates were cut into pieces about 2 x 12 mm with the gap across the center as shown in Figure 1. Then leads of 18 gauge insulated copper wire were soldered to the ends of the elements. Following this, the hygroscopic coating was applied, the soldered ends of the leads were insulated with a liquid polystyrene, non-conducting coating, and the sensing elements were aged for about 2 weeks before calibration.

A small, uniform-sized drop of the hygroscopic coating in 50% alcoholic solution was applied to each element using a thinly drawn-out pipette. If the same sized drop is applied to different elements, their calibration curves will be very nearly the same. The composition of the coating solution is given in Table 1.

Since any given element covers only 15 to 20 percent of the entire relative humidity range, a graded series of elements had to be prepared to cover the entire working range desired. Different ranges were covered by using different concentrations of lithium chloride in the coating mixtures -- more lithium chloride for low humidity elements and less for those to be used at high relative humidity levels.

Table 1. Composition of the hygroscopic coating for sensing elements.

Water	50 ml
95% Ethyl alcohol	50 ml
Polyvinyl acetate-alcohol[a]	2 gm
Lithium chloride	0.02 to 1.5 gm

[a] Solvar brand polyvinyl acetate, 36 percent hydrolyzed, secured from Shawinigan Products Corp., Shawinigan Fall, Quebec.

The Indicating Instruments Used

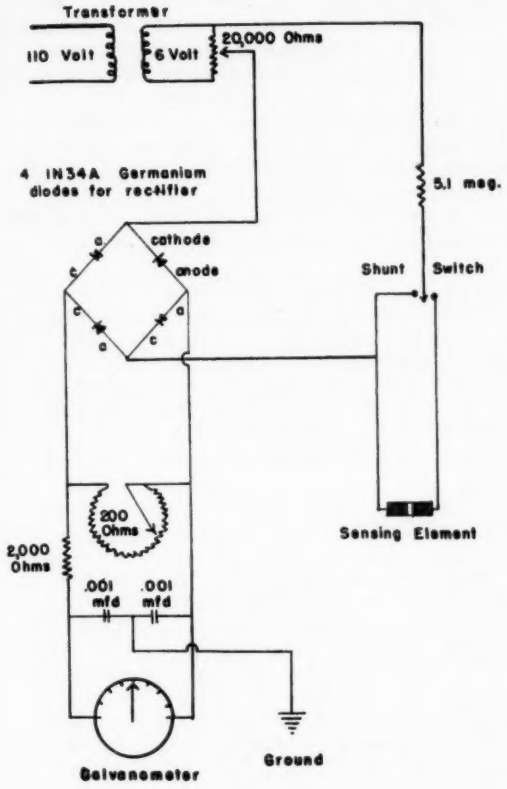
One of the instruments built to measure the current across the hygrometers was based on the original electrical circuits given by Dunmore (5). The circuit diagram used is shown in Figure 1.

Alternating current at 110 volts from a voltage stabilizer was transformed to 6 volts a.c. It was then passed through a 20,000 ohm voltage divider which could be used to make the fine adjustments necessitated by slight changes in line voltages. The current then passed either through the hygrometer element, or by means of a switch, across a shunt to the rectifier, and thence to the d.c. galvanometer. At the beginning of any group of readings a maximum galvanometer scale deflection of 100 mm was established by passing the current across the shunt and adjusting the voltage divider previously mentioned. Then the hygrometer could be switched into the circuit in place of the shunt, and a reading of less than 100 resulted, depending upon relative humidity conditions.

The rectifier used was composed of four germanium diodes, (Sylvania 1N34A), connected as illustrated. A full-wave selenium instrument rectifier had been tried at first, but was found to leak too much current to be usable. The germination diodes worked perfectly.

The galvanometer used was a Leeds and Northrup Type R, with separate lamp and scale, having a sensitivity of 0.003 micro-amperes per mm scale division and a critical external damping resistance of 2,000 ohms. By limiting the maximum scale deflection to 100 mm, the

[2] This was done by Evaporated Metal Films, Inc., 147 E. State St., Ithaca, New York.



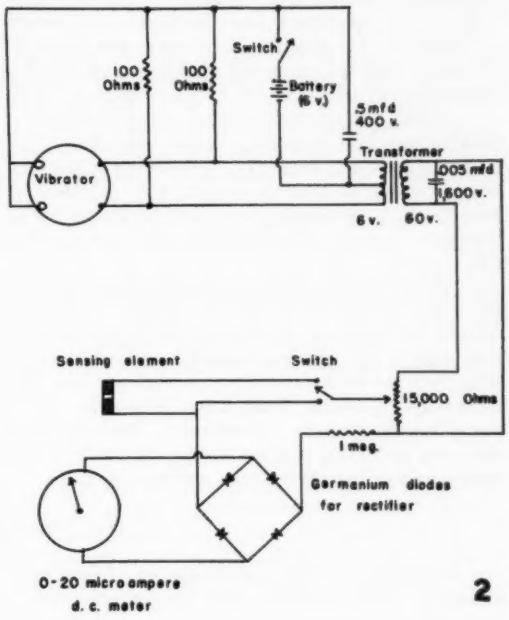


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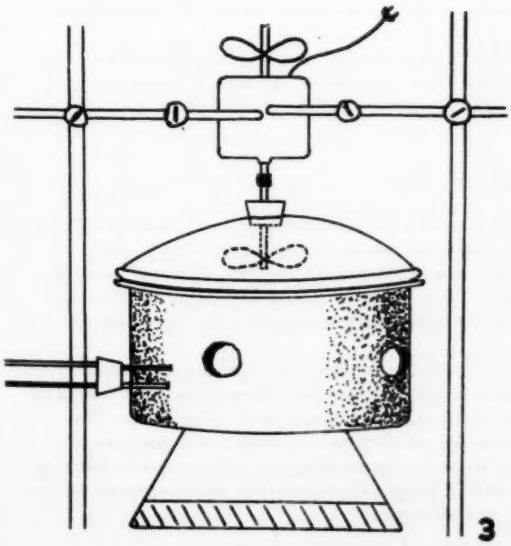
FIGURE 1. Circuit diagram for the laboratory indicating instrument.

FIGURE 2. Circuit diagram for the portable indicating instrument.

FIGURE 3. Calibration chamber used.

FIGURE 4. Micrometer used to measure relative humidity gradients near leaf surfaces.



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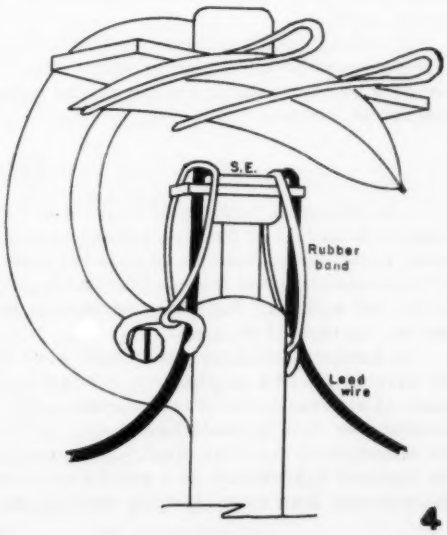

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maximum current that could ever flow across the hygrometer was 0.3 micro-amperes. Two 0.001 mfd capacitors were connected in parallel across the galvanometer contacts and grounded as shown in the diagram to reduce the deflections caused by extraneous electrical influences. Shielded lead wires to the hygrometers had been tried before installation of these capacitors, but could not be used due to the severe reduction in sensitivity that they introduced.

A second indicating instrument was constructed which was portable and could be used for making relative humidity measurements in the greenhouse or in the field. This was powered with a 6 volt dry battery. A Mallory 859 vibrator was used to give alternating current, which is necessary to prevent polarization of the hygrometer sensing elements. A 0-20 micro-ampere d.c. ammeter installed in the unit was used to indicate the flow of current. The wiring diagram is shown in Figure 2, and was given by the Staff of the Institute of Paper Chemistry (9).

The portable instrument was not as satisfactory as the laboratory instrument. One of the main reasons may be that the larger currents required to deflect the less sensitive meter caused an increase in resistance of the elements. A slight downward drift occurred in the readings if current was passed through the elements for more than a few seconds at a time. This fact made it necessary to standardize the time of reading to a uniform period, after current began passing through the elements, for critical work. Such a drift was not noted when using the laboratory instrument. With it, the currents flowing through the circuit were apparently so small that no change in resistance occurred even though the elements were used continuously for fairly long periods of time.

Calibration of the Elements

Calibration of the elements was found to be a very time-consuming job. Galvanometer readings were obtained when the hygrometers were exposed to controlled relative humidity atmospheres inside the desiccator-calibration chamber diagrammed in Figure 3. These were plotted against relative humidity values computed from wet and dry thermocouple readings obtained simultaneously inside the same chamber. The small fan inside the chamber was necessary to secure correct wet bulb thermocouple readings, but also served to cause rapid equilibrium between the sulfuric acid solutions placed in the base of the desiccator and the atmosphere contained therein. Different relative humidity conditions were obtained inside the chamber by using sulfuric acid solutions of different concentrations (8, 20). The desiccator had several holes in its sides so that 8 to 12 hygrometers mounted in rubber stoppers could be calirated simultaneously. After changing solutions, about 2 hours was allowed, with the fan running, for equilibrium to occur. Since any one element covered only about 15 percent of the entire relative humidity range, acid solutions were prepared at relative humidity intervals of about 3 percent, in order to establish several points on the calibration curve of each hygrometer used.

If an easier and quicker method of calibration were available, the usefulness of the hygrometers would be increased greatly. Use of a divided flow apparatus, in which separate streams of moist and dry air could be mixed in different proportions, would seem to have considerable promise.

The Elements in Use

The elements were used in several ways. They could be used simply to indicate ambient relative humidity of the atmosphere to which they were exposed. They were also used to make rapid measurements of relative humidity near the surfaces of leaves. Thirty seconds or less was required for equilibrium to be reached. The element could be clamped directly to the leaf with only 0.75 mm separating the moisture absorbing surface of the hygrometer and the surface of the leaf.

In addition, moisture gradients were measured near leaves by mounting an hygrometer on the moving pin of a mechanic's micrometer, so that relative humidity determinations could be made at accurately measured distances (0.75 mm to 10 mm) from the leaf, Figure 4. The micrometer setting could be adjusted by remote control so that the operator did not disturb the atmosphere near the plant. This was accomplished by connecting the micrometer holding the leaf and hygrometer to a second micrometer with a length of automible speedometer cable. Adjustments then were made by turning the latter instrument.

ADVANTAGES OF THE INSTRUMENT

This instrument appears to have several advantages over many previously reported devices for making relative humidity measurements near the surfaces of leaves or in small enclosed spaces. The sensing element is small enough that there should be no trapping or accumulation of transpirational moisture between the instrument and the leaf surface during routine use. Being an electrical method, it is remote reading, so that measurements may be made while leaves are subjected to experimental conditions or in controlled-environment chambers. The hygroscopic coating removes negligible quantities of moisture from the atmosphere (4); therefore the relative humidity conditions are not appreciably affected.

The instrument may be used in completely still air or in small enclosed spaces. Mass air movement is not necessary for attainment of equilibrium (as is required with psychrometric methods). Equilibrium is reached quickly, usually within less than one minute. With proper indicating instruments for measurement of the current, a sensitivity of 1/4 of one percent can be attained. It is doubtful, however, if the sensing elements could be calibrated to this degree of accuracy without very expensive equipment. An accuracy of $\pm$ one percent should be readily attained, however.

LIMITATIONS

For certain types of measurement, the instrument has definite limitations. The sensing elements can not be used reliably at relative humidity values of 95 percent or higher, or in locations where liquid water is likely to be deposited on them, because of the danger of removal of minute quantities of the hygroscopic coating, with consequent changes in the calibration of the elements. Because of this feature, the use of the instruments as permanently installed elements in the field would be precluded.

Each element covers only about 15 percent of the total relative humidity range; therefore, if the conditions being measured varied more than that amount, a series of elements would be necessary to cover the range.

For best results, a very low current density across the salt bridge is necessary. This results in an increased useful life of the individual sensing elements and freedom from drift during reading. In order to hold the current down, very sensitive galvanometers are needed for best results. Therefore, use of the instrument is best restricted to a laboratory or greenhouse where the delicate indicating devices may be properly supported and maintained. For the worker with a field problem this feature would be a distinct disadvantage.

Literature Cited

1. BRASTAD, W. A., and L. F. BORCHARDT. 1953. Electric hygrometer of small dimensions. Rev. Sci. Instr. 24: 1143-1144.
2. BUXTON, P. A., and K. MELLANBY. 1934. The measurement and control of humidity. Bul. Ent. Res. (London) 25: 171-175.
3. DELP, CHARLES J. 1954. Effect of temperature and humidity on the grape powdery mildew fungus. Phytopathology 44: 615-626.
4. DOBRIN, SAXE, 1949. The moisture transmission of packaging materials at low temperatures. Ph.D. Thesis (Unpublished) Cornell University, pp. 39-63.
5. DUNMORE, FRANCIS W. 1938. An electric hygrometer and its application to radio meteorography. Jour. Res. Natl. Bur. Stan. 20: 723-744.
6. DUNMORE, FRANCIS W. 1939. An improved electrical hygrometer. Jour. Res. Natl. Bur. Stan. 23: 701-714.
7. FRAMPTON, VERNON L., and KARLA LONGRÉE. 1941. The vapor pressure gradient above a transpiring leaf. Phytopathology 31: 1040-1042.
8. HEPBURN, J. R. I. 1928. The vapor pressure of water over sulfuric-acid-water mixtures at 25° C., and its measurement

by an improved dew-point apparatus. Proc. Phys. Soc. (London) 40: 249-260.

9. INSTITUTE OF PAPER CHEMISTRY STAFF. 1943. An electric sword hygrometer for measuring the relative humidity of air inside packages and other enclosures. Paper Tr. Jour. 116(24): 16-19; 117(1): 12-15.
10. INSTITUTE OF PAPER CHEMISTRY STAFF. 1946. Progress report on the development of two new electric methods for the measurement of water vapor permeability. Paper Tr. Jour. 122(1): 35-44.
11. LIVINGSTON, B. E. 1916. Improvements in the method for determining the transpiring power of plant surfaces by hygrometric paper. Plant World 19: 287-309.
12. MacDOUGAL, D. T. 1901. A new hygrometer suitable for testing action of stomata. Torreya 1: 18-20.
13. RAMSEY, J. A., C. G. BUTLER, and J. H. SANG. 1938. The humidity gradient at the surface of a transpiring leaf. Jour. Exp. Biol. 15: 255-265.
14. SHAW, LUTHER. 1935. Intercellular humidity in relation to fire-blight susceptibility in apple and pear. N. Y. (Cornell) Agr. Exp. Sta. Memoir 181: 1-40.
15. THUT, HIRAM F. 1939. The relative humidity gradient of stomatal transpiration. Amer. Jour. Bot. 26: 315-319.
16. Van den AKKER, J. A. 1947. Application of the electric hygrometer to the determination of water vapor permeability at low temperature. Paper Tr. Jour. 124(24): 51-56.
17. WEAVER, E. R. 1951. Electrical measurement of water vapor with a hygroscopic film. Anal. Chem. 23: 1076-1080.
18. WEAVER, E. R., and RALPH RILEY. 1948. Measurement of water in gases by electrical conductivity in a film of hygroscopic material -- use of pressure changes in calibration. Anal. Chem. 20: 216-229.
19. WEXLER, ARNOLD J. 1948. Divided flow type, low temperature humidity test apparatus. Jour. Res. Natl. Bur. Stan. 40: 479-486.
20. WILSON, R. E. 1921. Humidity control by means of sulfuric acid solutions, with critical compilation of vapor pressure data. Jour. Ind. Eng. Chem. 13: 326-331.
21. YARWOOD, CECIL E., and W. E. HAZEN. 1944. The relative humidity at leaf surfaces. Amer. Jour. Bot. 31: 129-135.

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BRIEF NOTES

A TECHNIQUE FOR TRANSFERRING INOCULUM THROUGH A FLAME TO REDUCE CONTAMINATION

By E. B. Lambert[1]

The technique described here was devised to reduce contamination during the transfer of cultures into wide mouth bottles. We have used this method for several years, and often it has enabled us to obtain a high percentage of pure cultures even when there is considerable spore-bearing dust in the air. The essential feature of this technique is the arrangement of a wing-topped bunsen burner so that it spreads a thin blue flame over the opening in the bottle that is being inoculated, as shown in Figure 1. Most kinds of inoculum -- including transfers from an agar culture -- may be passed through the flame without apparent injury. On the other hand, spores floating in the air near the opening of the bottle are either incinerated or driven away by the heat of the flame.

FIGURE 1. A wing-topped bunsen burner arranged to spread a flame over the opening of a bottle that is being inoculated through the flame.

Two persons should work as a team when a large number of bottles or flasks are inoculated. One moves the bottle into position and removes the plug with an asbestos glove while the other passes the inoculum through the flame. All the cotton plugs should be moistened generously with a water spray before the transfers are begun. Moistening reduces the burning of the plugs and immobilizes any stray spores that may be on the outside of the plugs. Each bottle is placed in front of the burner so that the flame completely covers the opening when the plug is removed. Once the proper position has been determined for the first bottle, those that follow can be brought into perfect alignment in a few seconds with the aid of guides fastened to the table top, as shown in the figure.

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NEW DISEASES FOR ILLINOIS

By G. H. Boewe and W. L. Klarman

A Cercospora leaf spot on Deutzia scabra which is caused by the fungus, Cercospora deutziae Ell. & Ev., was found by the junior author in Charleston, Coles County, Illinois on July 31, 1957. Approximately 50 percent of the leaves on this plant, the only affected plant found in the neighborhood, had been attacked by the fungus, but no defoliation had occurred.

A Cercospora leaf spot was found also on Abelia chinense near Vienna, Johnson County, Illinois on August 13. Neither Weiss, "Index of Plant Diseases in the United States" nor Chupp, "A Monograph of Cercospora", records a Cercospora on this host. The spots on the leaves measure up to 6 mm in diameter, are somewhat irregular in shape and are limited by the veins. The spots are dark, reddish-brown on the upper surfaces, turning to an ashen white with a narrow, purple border on maturity. On the lower surfaces of the leaves the spots are light tan turning to an even lighter tan on maturity, but they never appear as white as on the upper surfaces.

Anthracnose, caused by Colletotrichum spp., was found on the flowering stalks of several varieties of iris. The junior author collected the disease in Moweaqua, Shelby County, Illinois on July 28. It was collected on July 31, by the senior author in Champaign, Champaign County, Illinois. On the flowering stalks the disease is considered to be a weak parasite. In Champaign County the disease also was found causing a leaf spot, but only a few leaves were attacked.

Weiss, in "Index of Plant Diseases in the United States", does not report Colletotrichum on rhizomatous or cultivated irises. However, he lists Colletotrichum liliacearum (Schw.) Ferr. as occurring on the leaves of Iris cristata, a native species. The fungus found by the authors is very similar to C. liliacearum (Schw.) Ferr. and it may be the same species.

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BOOK REVIEW

"PLANT DISEASES DUE TO BACTERIA", by W. J. Dowson. Second Edition. xv + 232 pages. 1957. New York: Cambridge University Press. Price $6.50.

This second edition of bacterial diseases of plants is identical in format with the first edition which was published in 1949. Some of the changes and improvements include the addition of a chapter on the preservation of cultures, the increase by three in the number of maps showing geographical distribution of disease (to bring the number to 21), and the supplementing for some diseases of control practices, in particular the use of antibiotics, that have been developed in recent years. Apart from being thus brought up to date, the book remains essentially the same, with identical wording being used wherever feasible. Fortunately for the person with only a rudimentary background in bacteriology, Dr. Dowson confines himself to the simplest terminology possible.

The first part of the book, which covers four chapters, discusses the general nature and structure of bacteria, their classification and nomenclature, disease symptoms produced in the host, and principles and methods of bacterial investigation.

Part 2, made up of three chapters on media, tells briefly and explicitly how to prepare various culture media, explains the different biochemical activities of specific bacteria, and gives correct laboratory methods for obtaining good stains. The importance of the Gram reaction method of identification is stressed.

The third and last part, comprising six chapters, is concerned with diseases. One chapter each is devoted to the genera Corynebacterium, Pseudomonas, and Xanthomonas. Each chapter begins with the salient characters of the genus and the type species. The diseases are then listed individually according to the type of disease produced, that is, parenchyma, vascular, systemic, and gall-forming.

In lieu of a bibliography, at the conclusion of the discussion of each disease the author has listed his source material references.

Chapter 11 has been completely revamped. In view of the invalidating of the generic name Bacterium by the International Congress for Microbiology in 1953, as well as the lack of any universal agreement on a comprehensive group-genus for the coliform bacteria, the author has proposed the "temporary" use of the name Pectobacterium for bacteria that produce gas from sugars and possess pectic enzymes, and the name Erwinia for those bacteria having neither

characteristic.

Chapter 12 treats miscellaneous bacteria and includes some purely saprophytic forms.

The final chapter on preservation of cultures is new. In it are described three sure methods of preserving, without sub-culturing, bacterial cultures for a year or more, with the assurance that the organisms will remain viable and retain their original characters. This innovation makes possible the comparative studies of the same pathogen occurring in different countries and thus could be of immeasurable importance.

This second edition has been further enlarged by the incorporation into the text of about 20 diseases that did not appear in the first. Among these are some that occur only in the United States, a few recently found in Great Britain or in one of her possessions, and also one disease that previously had been thought to be caused by a virus.

At the end of the book, the figures, which in the main are photographs of disease symptoms, have been reduced from 40 to 30. The suggested reading list of 11 references also has been revised slightly.

There appear to be a few discrepancies between the two editions insofar as the tables are concerned. On page 134, for example, the results given for Table 4 differ in some cases with results given for the corresponding table in the first edition, particularly in the column showing nitrite formation. This applies also to Tables 5 and 6. Perhaps these differences are either intentional or incidental.

Plant Diseases due to Bacteria should prove useful to microbiologists in general, and in addition, undoubtedly it may serve as the answer to a real need for those plant pathologists charged with the accurate diagnosis of plant diseases resulting from a multiplicity of causes. -- HILDE McGRATH

ANNOUNCEMENT
RESULTS OF 1956 FUNGICIDE TESTS

"Results of 1956 Fungicide Tests" reprinted from a series of articles appearing in AGRICULTURAL CHEMICALS, February through August, may be purchased in bound and covered form for $1.00 per copy by sending orders with remittance to Dr. A. B. Groves, Department of Plant Pathology, Virginia Agricultural Experiment Station, R. R. 3, Winchester, Virginia. The publication of these results is under the sponsorship of the American Phytopathological Society. It is a continuation of the publication of results formerly provided through a Supplement of the PLANT DISEASE REPORTER, Plant Disease Epidemics and Identification Section, United States Department of Agriculture.

The Temporary Advisory Committee on Collecting and Disseminating Data on New Fungicide Tests of the American Phytopathological Society arranged for the recent publication of data and the continuation of a program for annual publications of Fungicide Test Results in the future. Dr. A. B. Groves, Department of Plant Pathology, Virginia Agricultural Experiment Station, Winchester, Virginia, will be in charge of this project during the current year.

CORRECTIONS

REPORTER, June issue (Vol. 41, No. 6), page 509: In Table 1, Unified group number 4, Reaction of Loros should be S, instead of R as printed.

REPORTER, September issue (Vol. 41, No. 9), page 794: In first line of text, the causal organism should be Cercospora citrullina Cke., not C. melonis as printed.

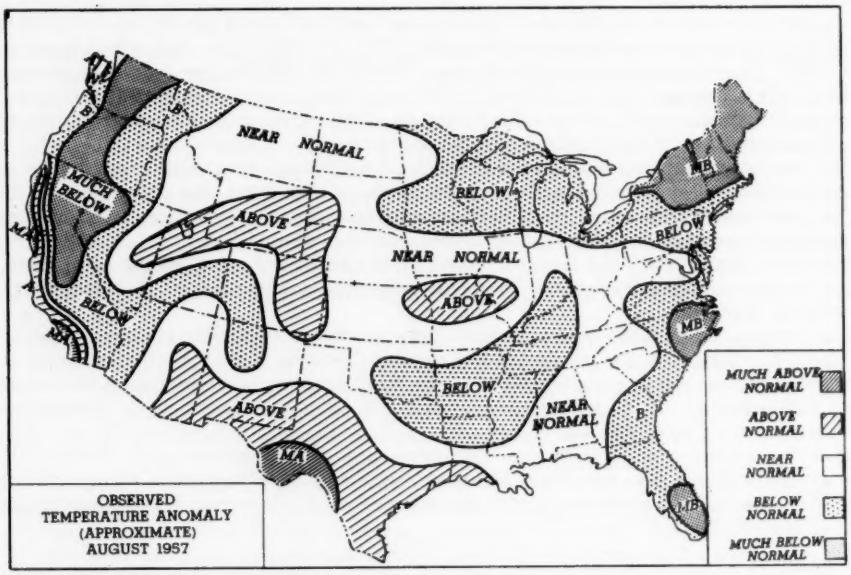
IN THIS ISSUE (Continued).

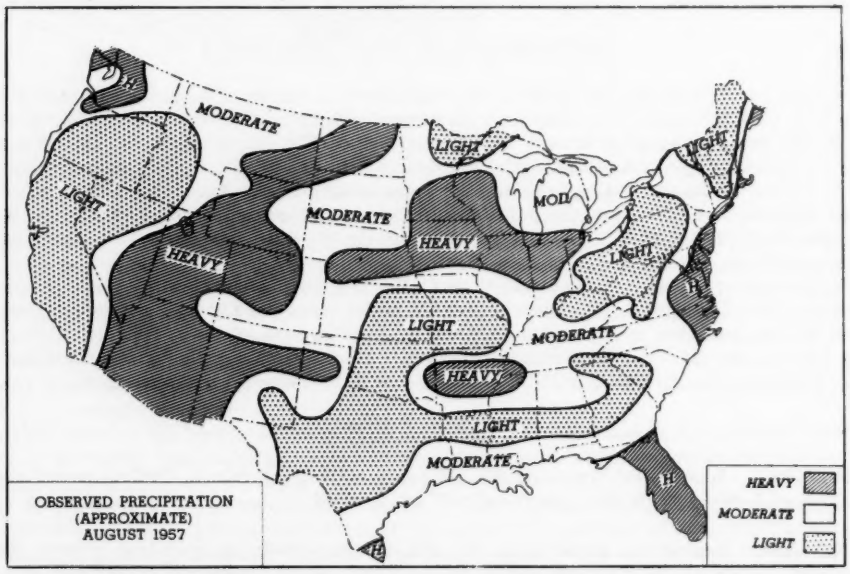
Brief notes, page 903: A technique for transferring inoculum through a flame to reduce contamination, by E. B. LAMBERT; New diseases for Illinois, by G. H. BOEWE and W. L. KLARMAN.

Book Review: "Plant Diseases Due to Bacteria", by W. J. Dowson, second edition, reviewed by HILDE McGRATH, page 904.

Announcement: "Results of 1956 Fungicide Tests" available, page 905.

Corrections: page 905. August Weather: page 906. Manuscripts for the Reporter, page 907.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.

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